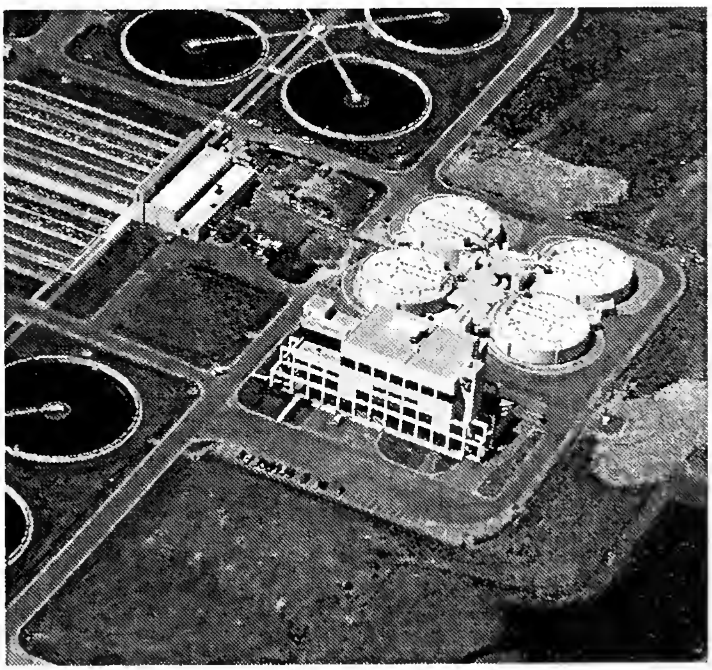
RESOURCE CONSERVATION

GUIDE TO Resource Conservation and Cost Savings Opportunities in the ➲ Municipal Water and Wastewater Sector



Ministry of the Environment

ISBN 0-7778-6908-X

Guide to Resource Conservation and Cost Savings Opportunities in the Municipal Water and Wastewater Sector

March 1998

Prepared for:

Industry Conservation Branch
Ministry of the Environment

by:

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Mississauga, Ontario

PIBS 3606

Printed on recycled paper

300 - 03 - 98

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Ontario Ministry of Environment
Public Affairs and Communication Branch
135 St. Clair Ave. W., Toronto, Ontario, M4V 1P5, Canada

March, 1998

Dear Reader:

The Ontario Ministry of the Environment in cooperation with the Water Environment Association of Ontario (WEAO) and the Ontario Water Wastewater Association (OWWA) are pleased to provide this copy of the *"Guide for Resource Conservation and Cost Savings Opportunities in the Municipal Water and Wastewater Sector"*. The guide was prepared jointly by the Ministry in partnership with WEAO and OWWA.

The guide identifies and promotes opportunities for conserving resources such as energy, water and materials, as well as reducing waste and preventing pollution in the municipal water and wastewater sector. By taking advantage of these opportunities, plant operators and municipal officials can lower operating costs and address infrastructure capacity problems.

Many parties in the water and wastewater business have an interest in resource conservation and environmental protection. This guide is aimed at a wide audience which includes, municipal officials, facilities managers, operators, contractors, suppliers of equipment and services, and engineering designers and consultants. By combining your knowledge and skills with the information contained in this guide, you can help keep the Ontario water and wastewater industry competitive and an efficient provider of an essential service.

We hope this guide is of value to you and your establishment.

Daniel Cayen
Director
Industry Conservation Branch
Ministry of the Environment

Nels Conroy
President
Water Environment Association of Ontario

Patricia Lachmaniuk
President
Ontario Water Works Association

Ontario

Water Environment Association of Ontario

PREFACE

SECTOR GUIDES

The Industry Conservation Branch (ICB) of the MOE develops generic Sector Guides for key industry sectors in Ontario to promote resource conservation, environmental protection and cost savings. The guides focus on identifying potential cost saving opportunities related to the efficient use of resources such as energy, water, and materials resulting in enhanced operational efficiency and pollution prevention. Recommendations for resource conservation are made with the objective of improving the "bottom line" of operating plants and protecting the environment. A sound technical and economic feasibility analysis of measures requiring capital expenditure should be conducted prior to considering implementation; this should ensure that a company's return-on-investment criterion is met. Recommendations in the guides that require little capital cost may be adopted directly by plant management to realize savings in operating costs.

The guides are prepared and distributed in partnership with industry associations to raise the awareness of Ontario industry about benefits from resource conservation and pollution prevention. In each case, an expert consultant was engaged by the ICB to prepare each guide with the advice of a Project Committee comprising of representatives from industry associations, private sector companies, utilities and government. Sector guides listed below are now available from the ICB:

Meat and Poultry Processing
Dairy Processing
Municipal Water and Wastewater
Soaps, Detergents and Related Products
Food Services
Adhesives, Paints and Coatings
Plastics Reprocessing
Automotive Parts Manufacturing
Plastics Processing
Office Buildings

This Guide for the Municipal Water and Wastewater sector was prepared by XCG Consultants Ltd. In addition to recommendations for resource conservation and environmental protection, the Guide provides information on the following related subjects:

> Sector profiles, resource use from a limited industry survey; infrastructure needs, main unit operations and processing equipment, process residuals; commercially available and emerging technologies and technology gaps, equipment suppliers, case histories and brief success stories in resource conservation.

It is hoped that the water and wastewater industry will find this Guide useful. Readers and users of the Guide are welcome to send their comments to Parkash Mahant, Clean Production Services Section, Industry Conservation Branch, MOE, 2 St. Clair Avenue West, 14th Floor, Toronto, Ontario, M4V 1L5, Fax No. (416) 327-1261.

DISCLAIMER

The views and ideas expressed in the Guide are those of the authors, XCG Consultants Ltd, and do not necessarily reflect the views and policies of the Ontario Ministry of the Environment. Mention of trade names, commercial products or supplier names does not constitute endorsement or recommendation for use by the Ministry. The Ministry encourages the distribution of information that strongly supports the concurrent promotion of resource conservation and pollution prevention measures leading to industrial and business competitiveness in Ontario. Resource conservation includes the conservation of energy, water and other input raw materials, as well as the reduction of waste or residuals.

Similarly, the generic opportunities presented by the authors of this Guide do not represent recommendations for implementation at specific sides. XCG Consultants Ltd and the MOE are not responsible for any such implementation without prior consultation and further detailed site evaluation by knowledgeable and competent experts. Users of information in the Guide should decide for themselves what is applicable to their respective operations.

ACKNOWLEDGMENTS

MOE and XCG Consultants Ltd would like to thank the following individuals and companies for their technical input, helpful comments, review of the draft copy of the Guide, and other support in the development of this Guide:

Paul Graham of Region of Sudbury, Jack Sonneveld of City of Chatham, Bernie Kuslikis and Robert Barnaby of Durham Region, Dan White of OCWA Kingston Office, David Robertson of Region of Ottawa-Carleton, Wayne Manley of Peterborough Utilities Commission, Harold Hodgson of Region of Niagara, Tony Smith of Region of Halton, Hiroshi Taniguchi of Metro Toronto, Don Cross of MOE Environmental Planning Analysis Branch, Ontario Hydro, B.C. Hydro, the Electric Power Research Institute, and Ronald Gemmell of the City of Barrie, Ontario.

The photograph on the cover was provided by David Umbach of CH2M Gore & Storrie Limited, Toronto.

We also thank all the plant operators and staff who returned the water and wastewater survey questionnaires. In addition, we express our appreciation to the two industry association, WEAO and OWWA, who were MOE partners in developing and distributing this Guide.

March, 1998

Industry Conservation Branch
Ministry of the Environment

Executive Summary

Purpose

The "Guide to Resource Conservation and Cost Savings Opportunities in the Municipal Water and Wastewater Sector" was developed to encourage water and wastewater facility managers and operators to consider and, where appropriate, investigate and implement resource use reduction and cost savings measures. The target audience for this guide ranges from plant operators, financial officers, supervisors and maintenance staff to utility managers, demand side management advisors and elected officials responsible for water and wastewater facilities. Consulting engineers should also find the Guide useful as a reference document.

The guide provides a series of generic process descriptions and information on energy, chemical and water conservation measures and technologies for the water and wastewater sector. The guide covers the following industry components:

- Water Treatment
  - Ground water supply
  - Surface water supply

- Water Distribution

- Wastewater Treatment
  - Primary treatment
  - Secondary treatment
  - Tertiary treatment

- Wastewater Collection

Structure

Sections 1 & 2	**Introduction** to the guide and general information on the municipal water and wastewater (MW&WW) industry sector.
Section 3	**Products, Generic Processes and Utilities**, provides generic information on water and wastewater facilities, including generic process diagrams of typical facilities. The diagrams identify where resources are used in the industry and where residuals are produced. The section reviews the use of energy, water, natural gas and chemicals in the MW&WW sector.
Section 4	**Resource Utilization**, discusses typical resource use within the water and wastewater sector in Ontario. Energy use profiles are provided including historic information on top energy using processes in the MW&WW sector.
Section 5	**Sector Survey**, reviews the information collected through MW&WW

	questionnaires sent to plant operators and supervisors and provides typical resource usage data for comparison. Operators can review the resource usage at their facility and identify potential areas for conservation.
Section 6	**Generic Opportunities for Resource Conservation and Cost Savings**, identifies resource conservation measures and provides brief descriptions of each. Generic measures that impact the entire industry as well as process specific conservation measures are presented.
Section 7	**Innovative Technologies**, discusses resource conservation technologies that are not necessarily new, but are not widely applied in Ontario and may merit consideration. New technologies are cross-referenced in Section 6 for each appropriate conservation measure.
Section 8	**Priorities and Implementation**, reviews and addresses issues regarding implementation of conservation measures through a "Management Program". Priority items and selection criteria are also discussed to assist operators in the evaluation of conservation opportunities for implementation.
Section 9	**Successful Resource Conservation Applications**, provides a number of success stories identifying applications of conservation measures that achieved savings in MW&WW facilities across Canada and the United States. Success stories are cross-referenced in Section 6 for each appropriate conservation measure.
Section 10	**Other Useful Information**, summarizes additional information relevant to the MW&WW industry in Ontario, including industry associations and other agencies, publications and references used in the development of the guide, and environment management systems.

Legislation, Regulations and Standards relevant to the MW&WW sector in Ontarioare listed in Appendix A . Appendix B contains data in a grahical format obtained from the MW&WW sector survey questionnaires as mentioned in Section 5. Appendix C has information on **Ontario Equipment Suppliers** as a listing of members of Ontario Water Works Association and Ontario Pollution Control Equipment Association.

HIGHLIGHTS

Using Section 6, readers can review **conservation opportunities** that may offer cost savings for water and wastewater facilities. Some opportunities can be implemented immediately at low or no cost. Other opportunities will require more detailed analysis for specific facilities to evaluate potential savings. Typically, the conservation measures that should be considered with significant potentials for resource use reduction and/or cost savings are:

Energy Conservation Opportunities

- High efficiency motors and/or variable speed drives which can offer average annual savings of 3 to 5 % and 15 to 50 %, respectively.

- Instrumentation and controls to monitor operating conditions and adjust system performance, particularly in the operation of pumps and blowers.
- Optimizing aeration processes, which are the largest user of energy in the wastewater sector. Conservation opportunities include:
  - High efficiency aeration systems, such as fine pore diffused air systems, which can offer savings ranging from 9 to 40 %.
  - On/Off Aeration.
  - Pure Oxygen use in Aeration.
  - Biological Phosphorus or Nutrient Removal
- Energy recovery, which can even provide complete energy requirements in small plants. Techniques discussed include:
  - Cogeneration
  - Air and Liquid Heat Exchangers
  - Solar Walls
- Optimized scheduling and off-peak operation, specifically for pumping facilities in water distribution systems.
- Negotiating energy charges and rate structures with local utilities.

Chemical Conservation Opportunities

- Instrumentation and controls to monitor current operating parameters and adjust chemical addition. Technologies reviewed include:
  - SAADA Control
  - Flow Pacing
  - Optimized Dosing
- Evaluation of alternative chemicals to maximize performance and reduce use.
- Evaluation of bulk purchasing opportunities.

Water Conservation Opportunities

- Reduce filter backlashing frequencies and durations to provide significant water savings.
- Use effluent water instead of potable water for foam control, chemical makeup, chemical transport and other uses in wastewater facilities.

Innovative technologies that are gaining acceptance in Ontario and warrant consideration are described in Section 7. They include:

- Specific Parameter On-Line Measurement

- Streaming Current Monitors
- High Velocity Mixing Systems
- Bacterial Regrowth Monitor
- Biological Phosphorus Removal
- Autothermal Thermophilic Aerobic Digestion
- Membrane Bioreactors
- Raw Water Control and Reservoir Mixing
- Alternate Disinfection
- Membrane Filtration
- Membrane Aeration
- Biological Nitrogen Removal
- Outfall Micro-Turbines
- Oxidation Reduction Potential

Follow Up Services Available

The Industry Conservation Branch (ICB) of the Ministry of the Environment can provide assistance to a company to develop a resource conservation plan. One of the services offered by the ICB is a Utility Bill Analysis which is the first step in conducting a resource use assessment of an enterprise. The analysis provides a quick indicator of an individual company's energy and water consumption patterns and the efficiency of its operations. Immediate savings can often be identified in the analysis of gas, electricity, oil and propane, and water consumption patterns. A follow-up plant "walk-through" analysis identifies potential operational savings in energy, water and other process-related resource use.. Companies can then pursue resource conservation opportunities using their own technical staff or with the assistance of an external consultant.

For ICB services, please contact:

Manager, Clean Production Services Section
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1. INTRODUCTION

Municipal water and wastewater (MW&WW) treatment plants serve the majority of Ontario communities. The water and wastewater industry consumes large amounts of energy, water and chemicals. Billions of dollars are spent each year operating and maintaining these facilities. For example, in 1994 the industry spent $5.9 billion in operating costs and $4.7 billion in capital expenditures. Significant potential exists to reduce energy, water and chemical use through implementation of efficiency measures.

To provide a guide for the MW&WW treatment industry in identifying and assessing efficiency opportunities, this document has been prepared for the Industry Conservation Branch (ICB) of the Ontario Ministry of Environment (MOE). The Guide also covers water supply and distribution and wastewater collection facilities. Support and endorsement for the preparation of this guide was provided by the Water Environment Association of Ontario (WEAO), the Ontario Water Works Association (OWWA), and Ontario Hydro.

The Guide presents the current status of the industry with respect to energy, chemicals and water consumption, and reviews measures for improving energy, water and chemicals use efficiency. An important feature is a description of innovative technologies available for implementation. The authors also include an evaluation and implementation strategy for undertaking cost-effective resource conservation projects in the MW&WW sector. A number of success stories are included to illustrate the implementation of efficiency measures.

This guide was developed for the purpose of encouraging water and wastewater facility managers and operators to consider and, where appropriate, investigate the potential for implementation of resource efficiency and cost savings measures. The target audience for this guide includes personnel ranging from plant operators, supervisors, financial officers and maintenance staff to utility managers and elected officials responsible for the operation of water and wastewater facilities. Consulting engineers should also find the Guide a useful reference source.

The adoption of resource conservation measures discussed in this document may be looked upon as a prudent business decision to reduce operating costs and improve the "bottom line". Implementation of these measures can also be used to ameliorate infrastructure capacity problems and thus delay or obviate the need for certain capital expenditures which otherwise would have to undertaken in the immediate future. A number of MW&WW treatment plants in Ontario are recognized leaders in resource conservation and cost savings; their contribution is acknowledged in this Guide. In other plants, much work needs to be done to take advantage of available technological opportunities.

2. SECTOR PROFILE

A brief profile of the municipal water and wastewater sector is provided in this section of the guide. Sector activities are described and industry statistics are reviewed. This section also reviews legislation relevant to the sector and presents sector economics and emerging issues.

2.1 Sector Activities

The MW&WW facilities are responsible for providing drinking water and disposing of wastewater for the residential, commercial and industrial sectors in Ontario. The two components of the sector evaluated in this review specifically were:

1. *Water Treatment Industry* - responsible for the treatment of water to meet drinking water standards, and distribution of the treated water through transmission trunk mains and local distribution mains to consumers in a community.

2. *Wastewater Treatment Industry* - responsible for the collection of wastewater through local collection sewers and gravity/force main trunk sewers and treatment of wastewater to meet receiving water standards.

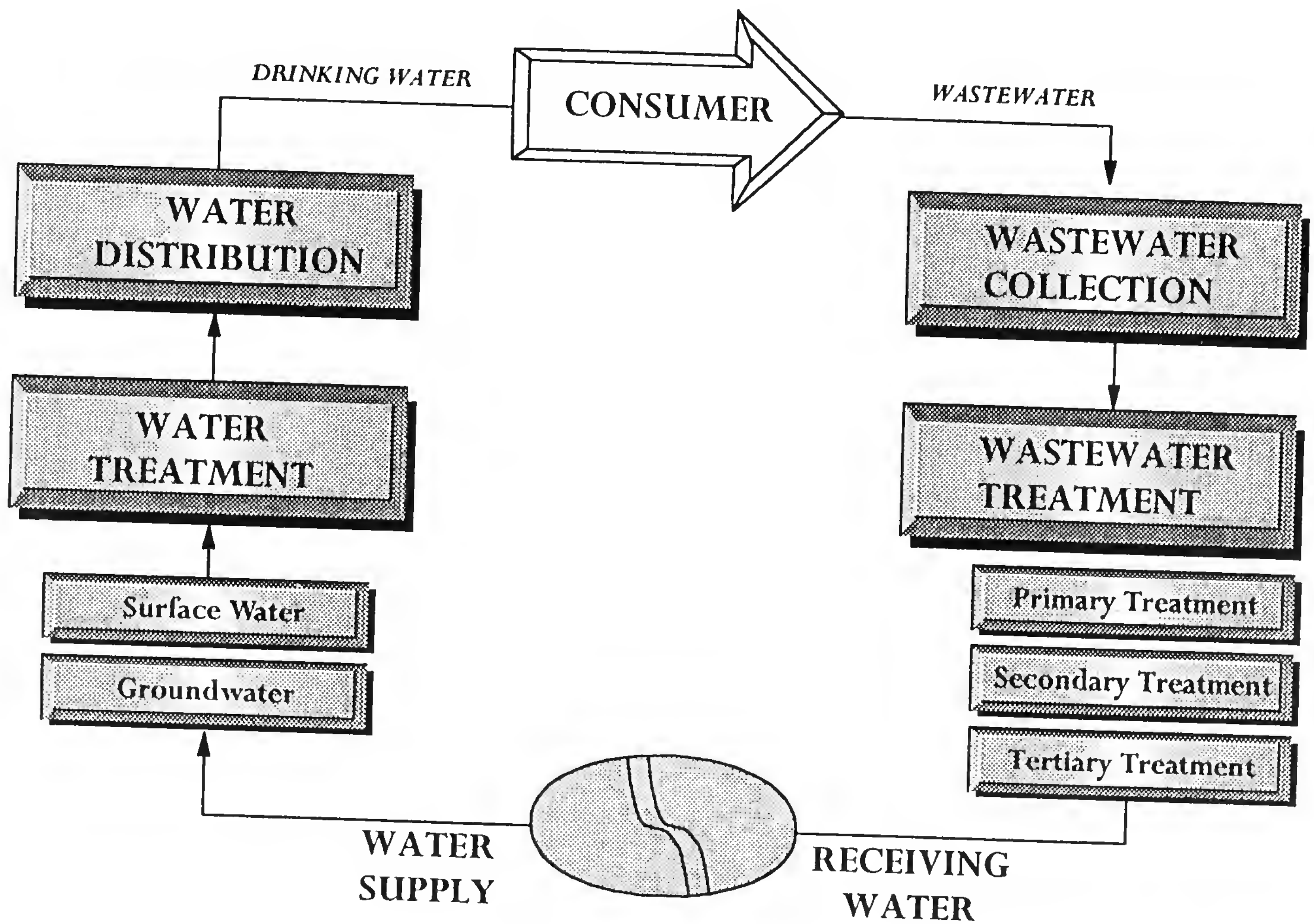
The schematic in Figure 2.1 illustrates the relationship between the water and wastewater treatment components of this sector. The processes considered in this Guide are presented in this figure and include:

- Water Treatment
  - Ground water supply
  - Surface water supply
- Water Distribution
- Wastewater Treatment
  - Primary treatment
  - Secondary treatment
  - Tertiary treatment
- Wastewater Collection

This report includes a review of information for both the water and wastewater industry. The majority of the report findings are separate for both industries; however, in some cases results are identified as common to both. For example, water conservation reduces water treatment requirements and, in-turn, reduces wastewater treatment demands.

Figure 2.1

WATER AND WASTEWATER SECTOR ACTIVITIES



2.2 Number and Sizes of Plants

The MOE's municipal water and wastewater treatment plant databases for 1997 provided the basis for the sector profiling. The databases present information for 667 water treatment plants and 443 wastewater treatment plants in Ontario. Plant names and corresponding service area are available from the MOE.

Using the information provided in the MOE databases, plant sizes were distinguished by service population. Plants were categorized as follows:

- UNKNOWN - no service population information provided
- VERY SMALL - 1 to 1,000 service population
- SMALL - 1,000 to 10,000 service population
- MEDIUM - 10,000 to 100,000 service population
- LARGE - 100,000 to 500,000 service population
- VERY LARGE - >500,000 service population

Figures 2.2 and 2.3 show the breakdown of Ontario plants by service population for water and wastewater treatment, respectively. This information is also summarized in Table 2.1. Very small and small plants (servicing <10,000 people) comprise approximately 80% of the plants in Ontario.

Table 2.1
Distribution Of Plants By Size In Ontario (1997)

Plant Size	Number of WTP's	Number of WWTP's
Unknown	49	13
Very Small	312	114
Small	224	235
Medium	62	66
Large	13	13
Very Large	7	2
Total	667	443
Service Population	8,387,890	8,195,409
Percent Serviced	83%	81%

WWT-------Water Treatment Plants

WWTP-----Waste Water Treatment Plants

Figure 2.2

WATER TREATMENT PLANTS - % POPULATION SERVED

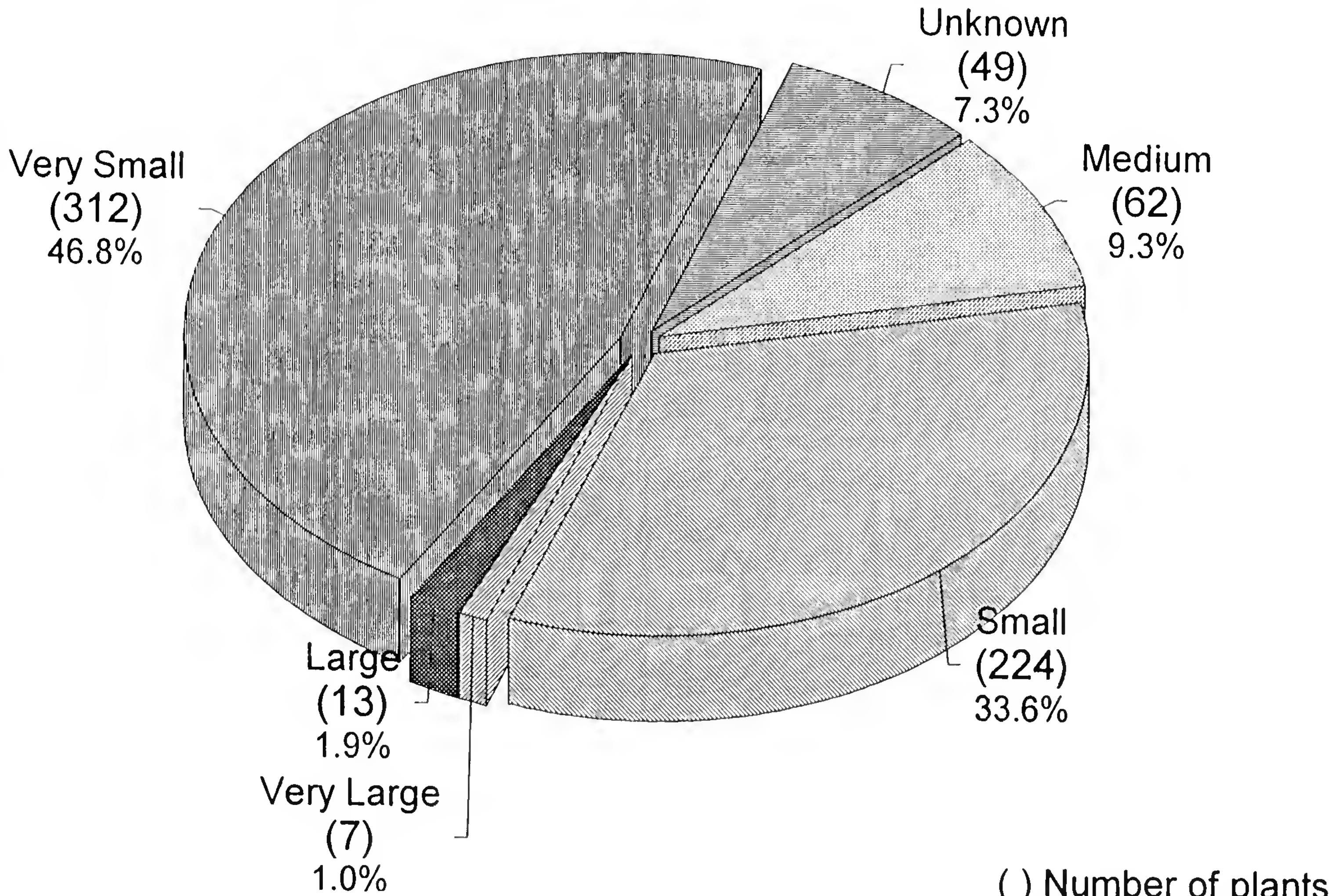
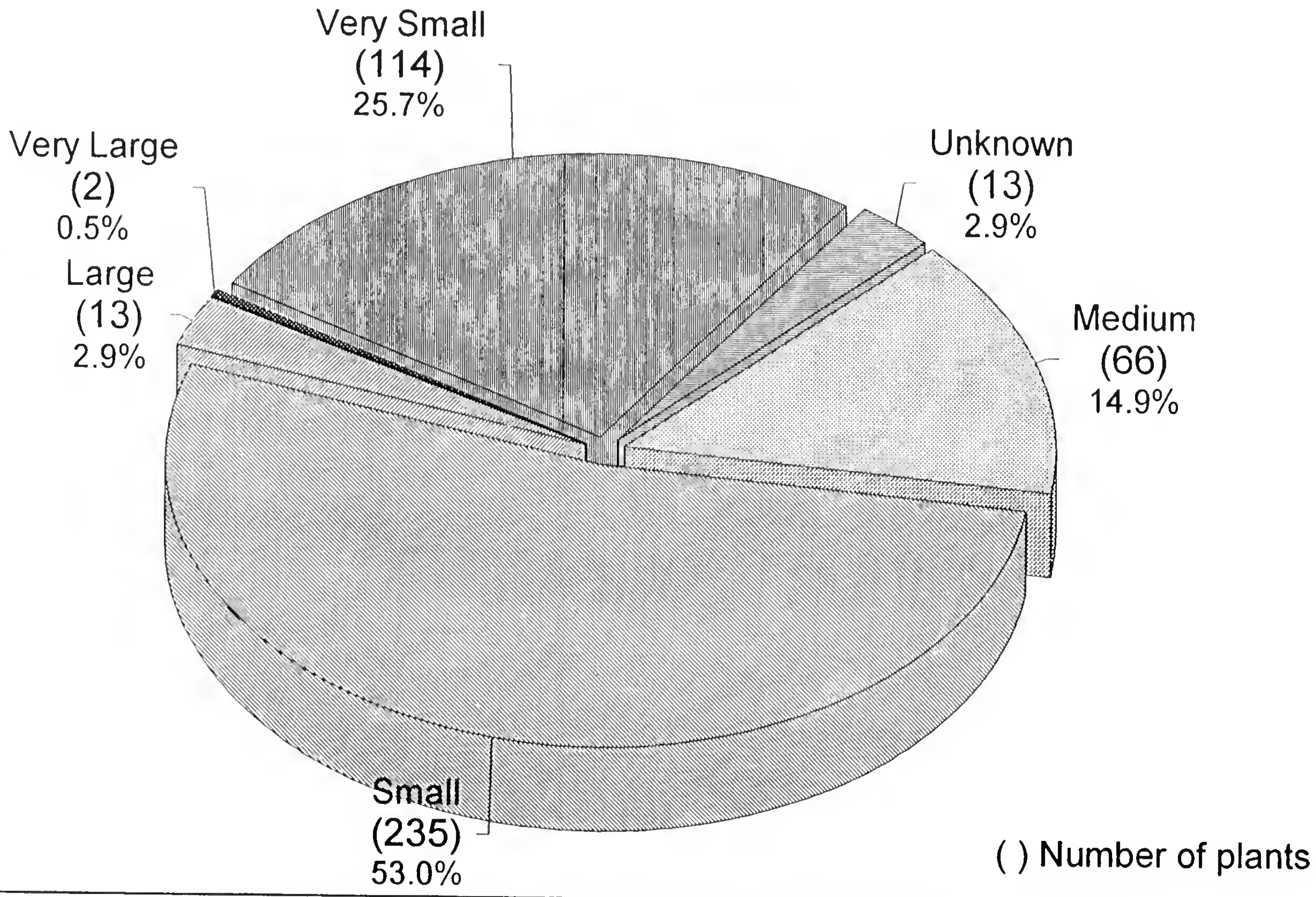


Figure 2.3

WASTEWATER TREATMENT PLANTS - % POPULATION SERVED



Treatment facilities are further distinguished by the level of treatment applied at each plant. Figures 2.4 and 2.5 show the breakdown of Ontario plants by type for water and wastewater facilities, respectively.

2.3 Current Economic Status

Canada-wide, estimates for 1994 put the operational costs of water and wastewater services at $5.9 billion and capital expenditures at $4.7 billion [5]. These costs also include water distribution and collection systems including water mains and sewers, pumping stations, land access and rights of way, excavation and restoration.

Using population figures provided by Statistics Canada [9], approximately 36% of Canada's population resides in Ontario. Assuming equal distribution of costs, this equates to an operational cost for water and wastewater services in Ontario of approximately $2.1 billion and capital expenditures of approximately $1.7 billion for 1994. These figures could actually be higher because Ontario has a large percentage of population served by communal systems, and a large percentage of wastewater plants providing secondary and tertiary treatment, which costs more.

2.4 Relevant Legislation, Regulations and Standards

The water and wastewater industry is governed by a number of regulatory instruments at the federal, provincial and municipal level. Appendix A provides an overview of the legislation, regulation and standards that impact the water and wastewater industry. In this appendix, a brief description of the relevant governing documents is presented under three sections relating to water resources, air resources and solids. An Ontario Hydro study on water and wastewater treatment facilities in Ontario [6] reviewed many of these documents, their comments are included below.

2.5 Emerging Sector Issues

Growing concerns over drinking water quality and condition of receiving waters makes it critical for water and wastewater treatment plants to address the needs of the public. In general terms, some of the current and emerging issues faced by the water and wastewater industry are:

- Meeting MOE and other guidelines, policies and regulations.
- Maintaining or improving cost-effectiveness in the operation and maintenance of facilities.
- Meeting stringent drinking water quality requirements.
- Meeting stringent receiving water requirements.
- Meeting stringent air emissions standards.
- Improving levels of service including improved water quality and reduced service interruptions.
- Maintaining reasonable and effective cost controls and customer service while meeting requirements and standards of environmental protection.

- Aging infrastructure and capacity problems
- Market place competition in building and operating water and wastewater treatment plants.
- Reduced levels of available funding.
- Alternate strategies for water supply and wastewater management, e.g. privatization.

Figure 2.4

WATER PLANTS - TYPES OF TREATMENT

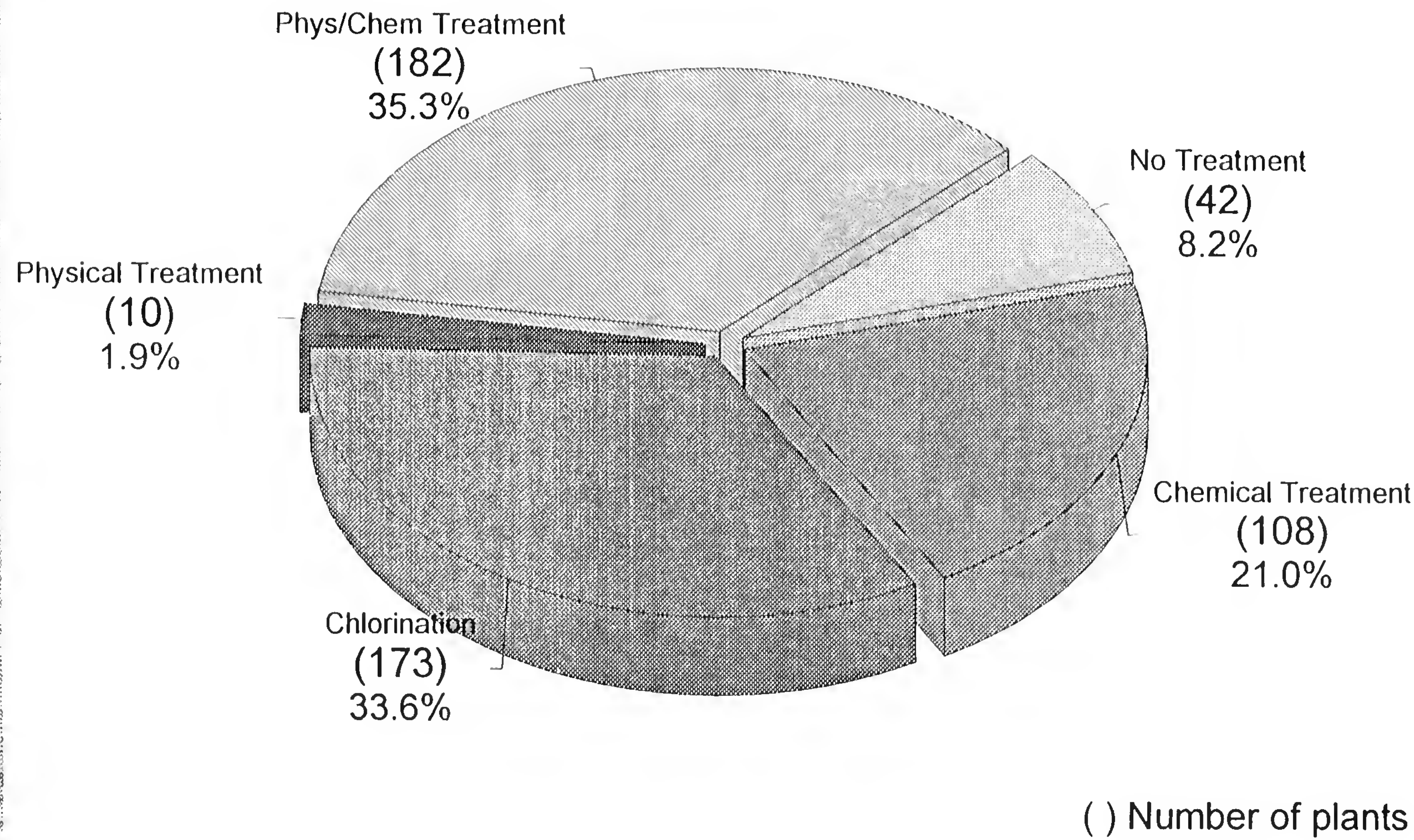
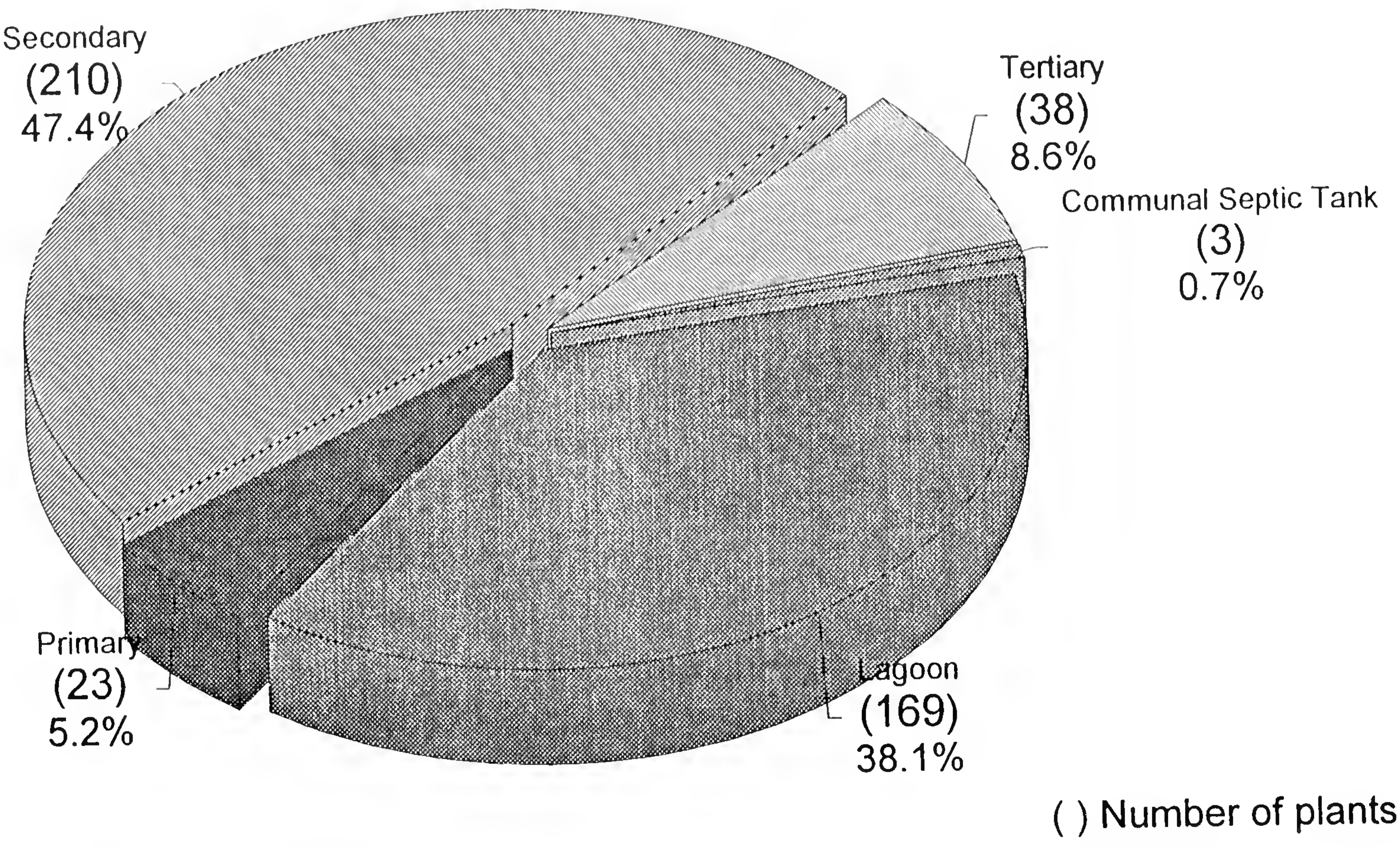


Figure 2.5

WASTEWATER PLANTS - TYPES OF TREATMENT



3. PRODUCTS, GENERIC PROCESSES AND UTILITIES

This section provides a generic description of the municipal water and wastewater industry. Certain limitations, which should be recognized when using a generic approach, and which have been outlined in other sector guides [7] are:

- A generic approach is based on a high degree of homogeneity between and among processes and resource utilization patterns of different plant operations within a specific sector. Significant variability can exist between plants, even those using the same processes and using the same chemicals.
- A generic approach does not consider site-specific limitations and factors. This restraint is very important when considering potential improvement technologies which will have varying effects at different plants.
- A generic approach may be overly generalistic and simplistic in nature. The details and specifics of processes, equipment and technologies are not addressed in this type of approach.

As a result, this guide should be used as a starting point for site-specific evaluations.

3.1 Generic Processes and Unit Operations

There are a limited number of processes used in Ontario for treating water and wastewater. Generic flowsheets illustrating the major processes used in Ontario are presented in the following figures:

Figure 3.1 - Groundwater Treatment

Figure 3.2 - Surface Water Treatment

Figure 3.3 - Water Distribution

Figure 3.4 - Wastewater Treatment

Figure 3.5 - Wastewater Collection

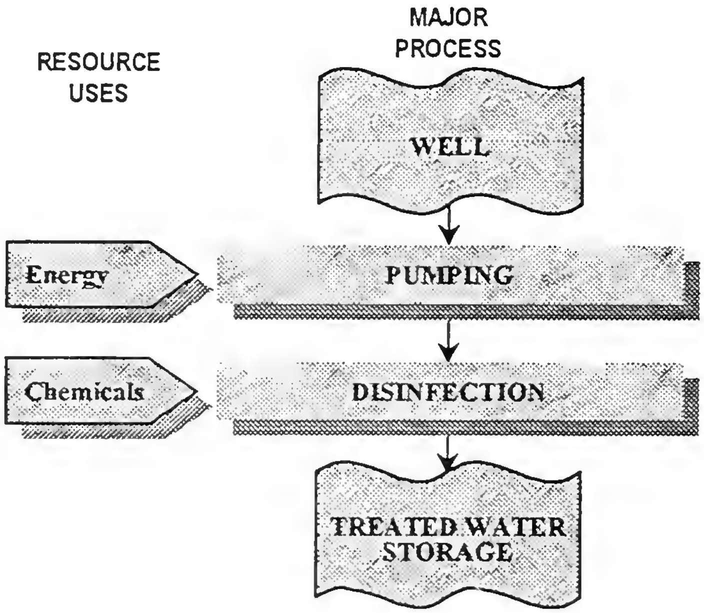
Each of the figures is presented in the form of block diagrams with conventional processes identified in each block.

3.2 Products and By-Products

The processes using energy, water and chemical are identified in the generic flowsheets. Addition points for each resource are shown in Figures 3.1 to 3.5. In Section 6, the energy, chemical and water use conservation measures in addition to residual issues that are associated with each process block are described in detail.

Figure 3.1a
GROUNDWATER TREATMENT

DISINFECTION ONLY



SOFTENING-TREATMENT

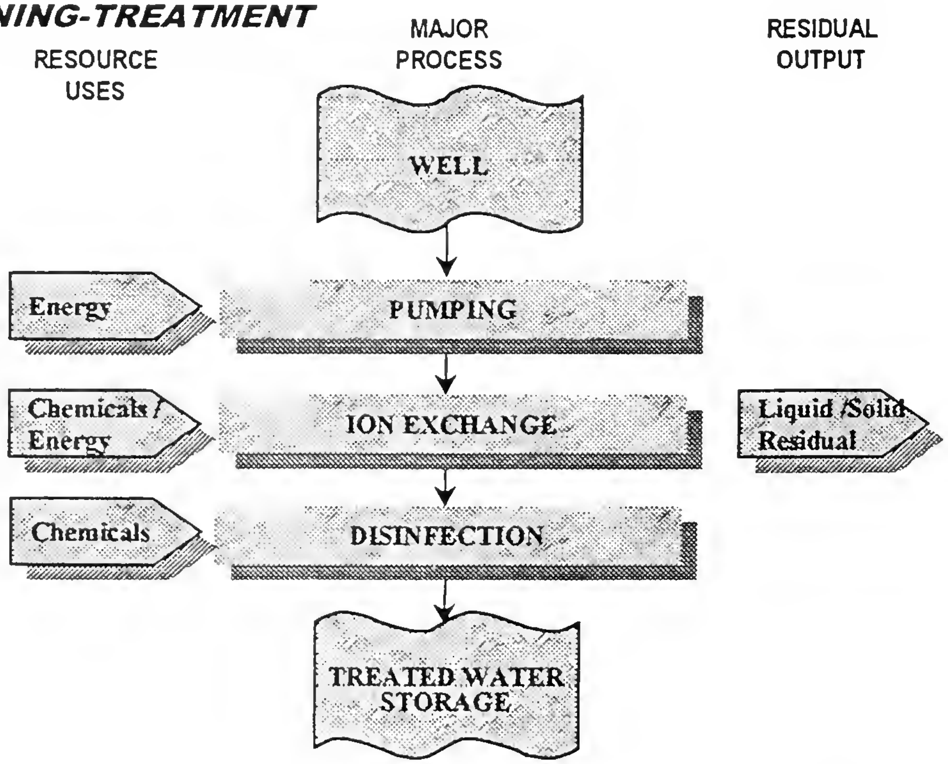


Figure 3.1b
GROUNDWATER TREATMENT

IRON/MANGANESE TREATMENT

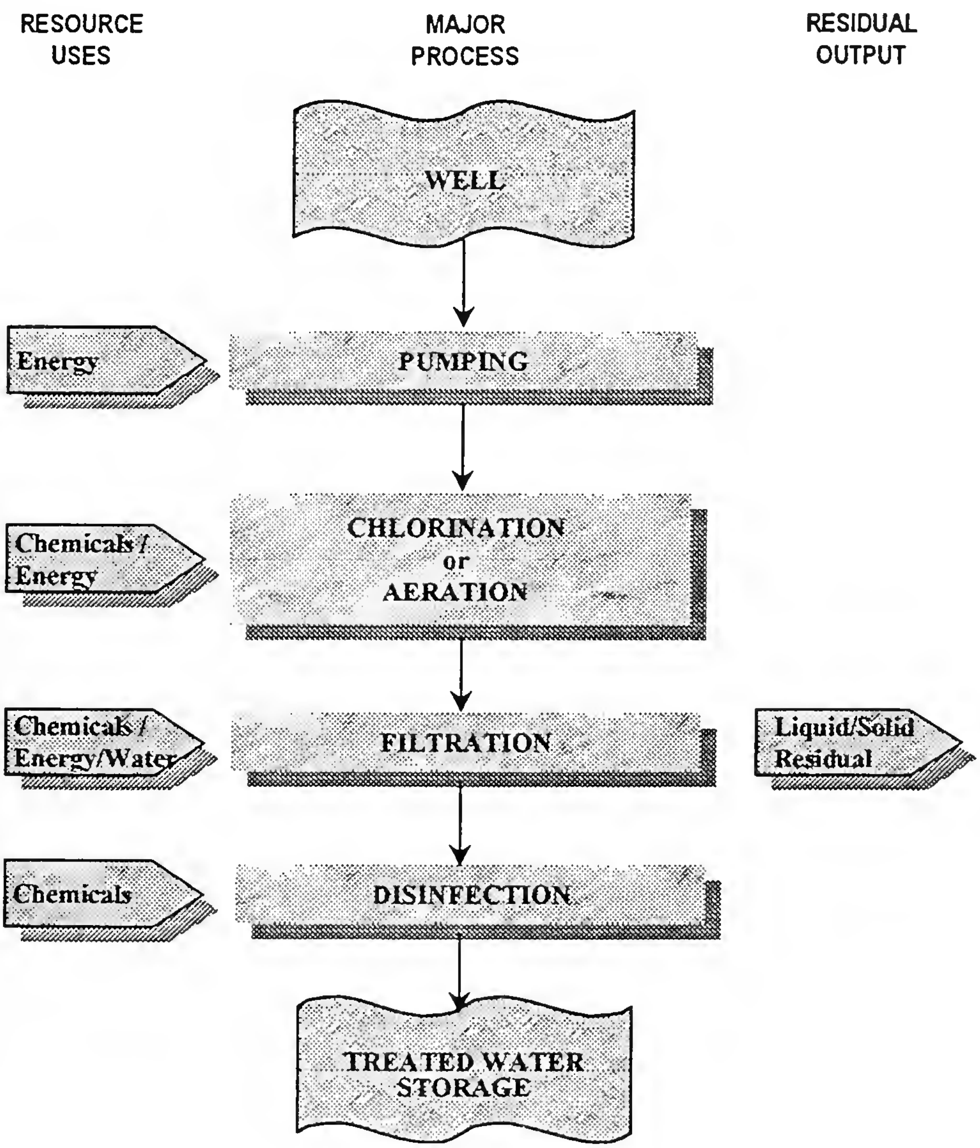


Figure 3.2a
SURFACE WATER TREATMENT

CONVENTIONAL TREATMENT

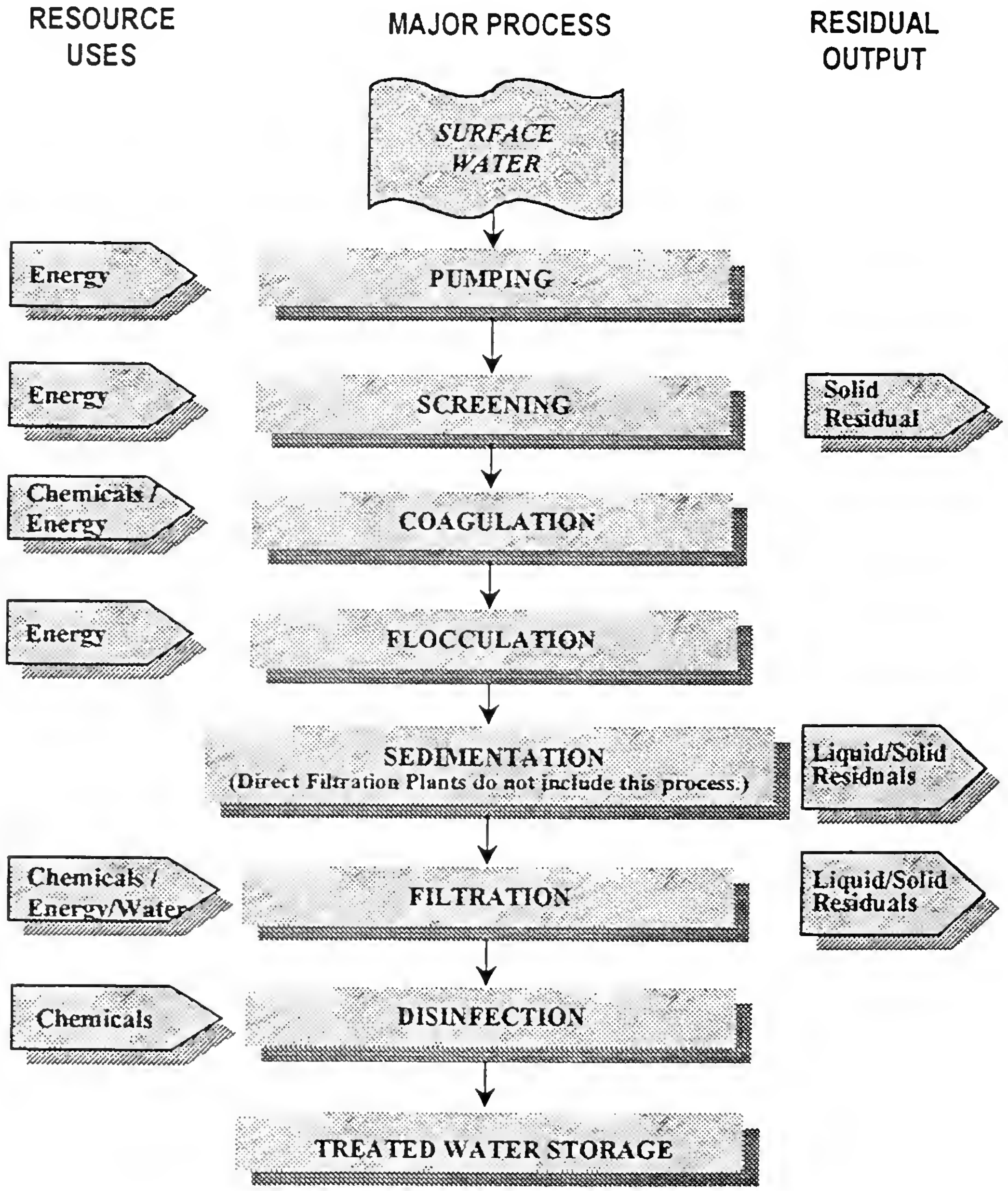


Figure 3.2b
SURFACE WATER TREATMENT

ADDITIONAL TREATMENT PROCESSES

RESOURCE USES	MAJOR PROCESS	RESIDUAL OUTPUT
Energy	OZONATION	
Energy	AERATION	
Chemicals	DECHLORINATION	
Chemicals/ Energy	ION EXCHANGE	Liquid Residual
Chemicals	CHEMICAL PRECIPITATION	Liquid/Solid Residual
Chemicals	SEQUESTERING	
Chemicals	CHEMICAL OXIDATION	Liquid/Solid Residual
Chemicals/ Energy	POWDERED ACTIVATED CARBON	Liquid/Solid Residual
Chemicals/ Energy	GRANULAR ACTIVATED CARBON	Solid Residual
Chemicals	FLUORIDATION	
Chemicals/ Energy/Water	RESIDUAL / SLUDGE TREATMENT	Liquid/Solid Residual

Figure 3.3
WATER DISTRIBUTION

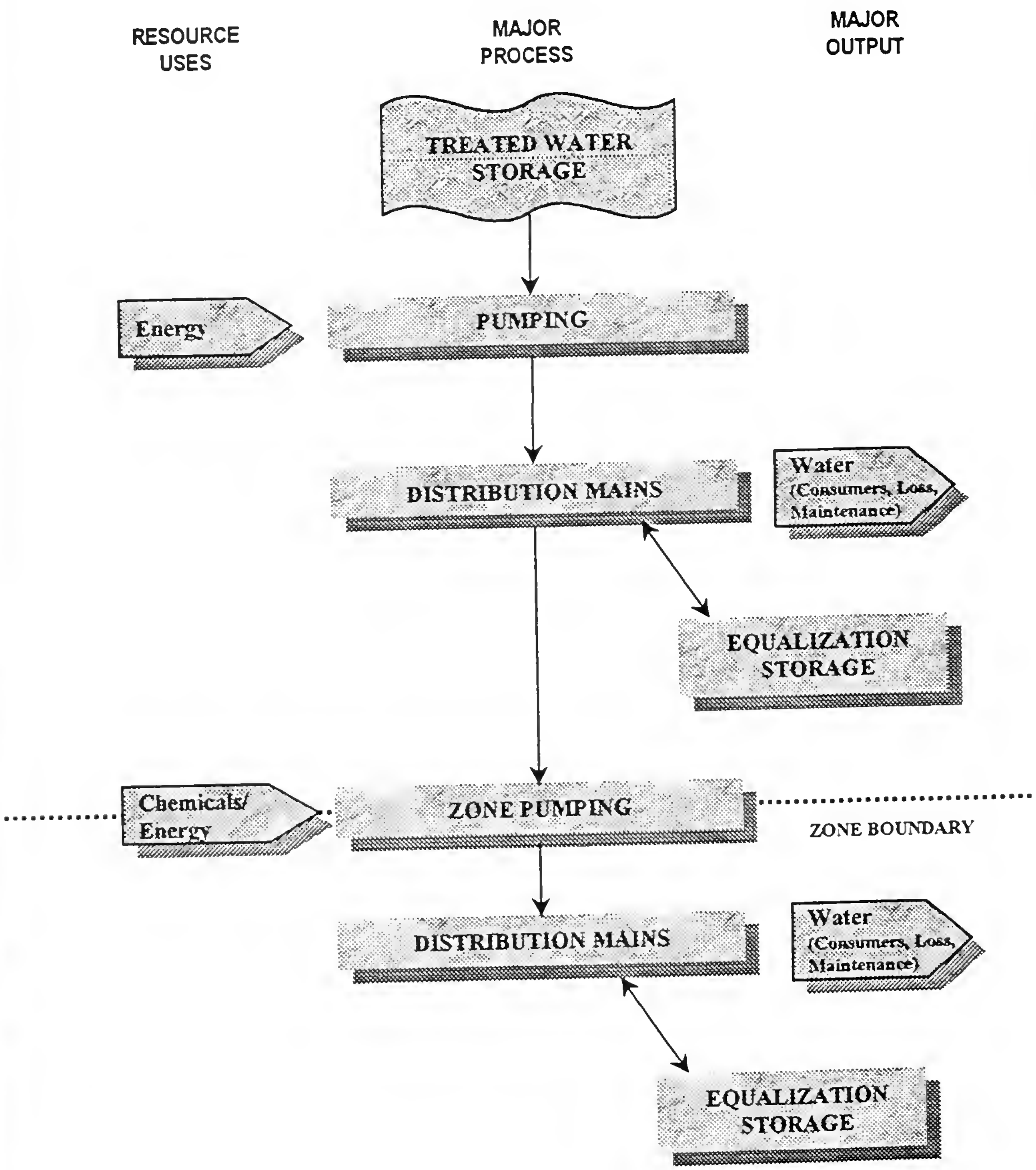


Figure 3.4a
WASTEWATER TREATMENT

CONVENTIONAL TERTIARY TREATMENT

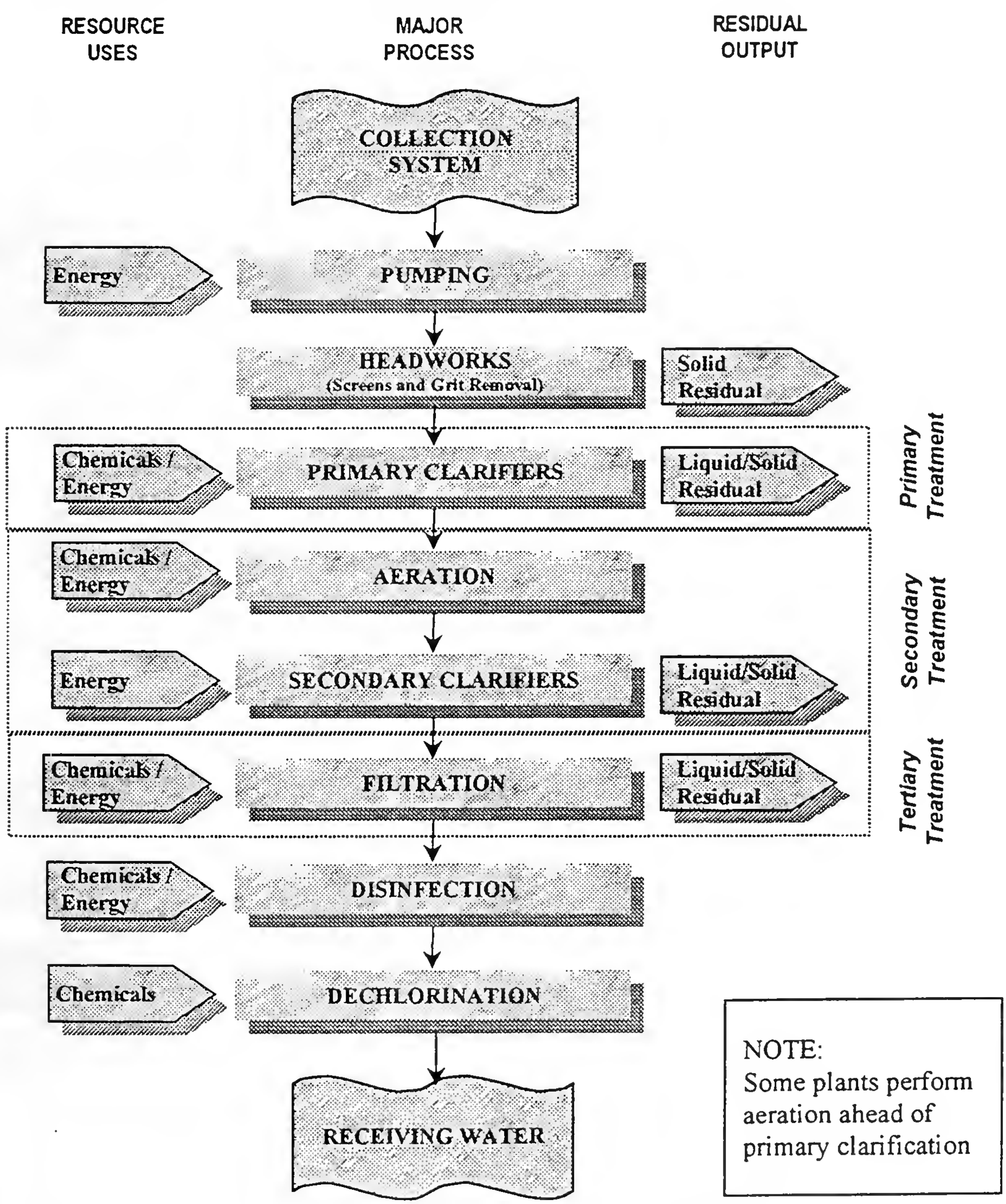


Figure 3.4b
WASTEWATER TREATMENT

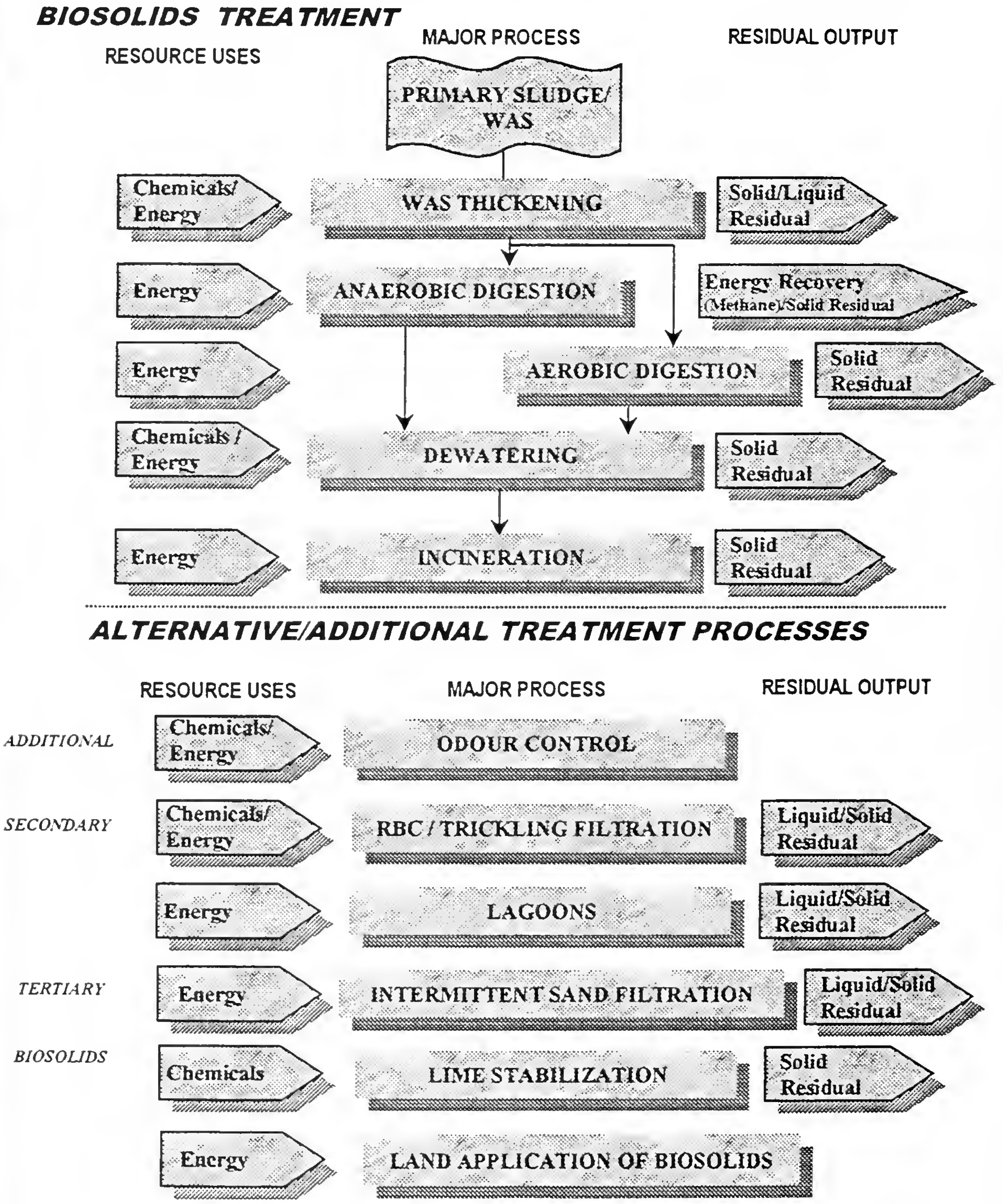
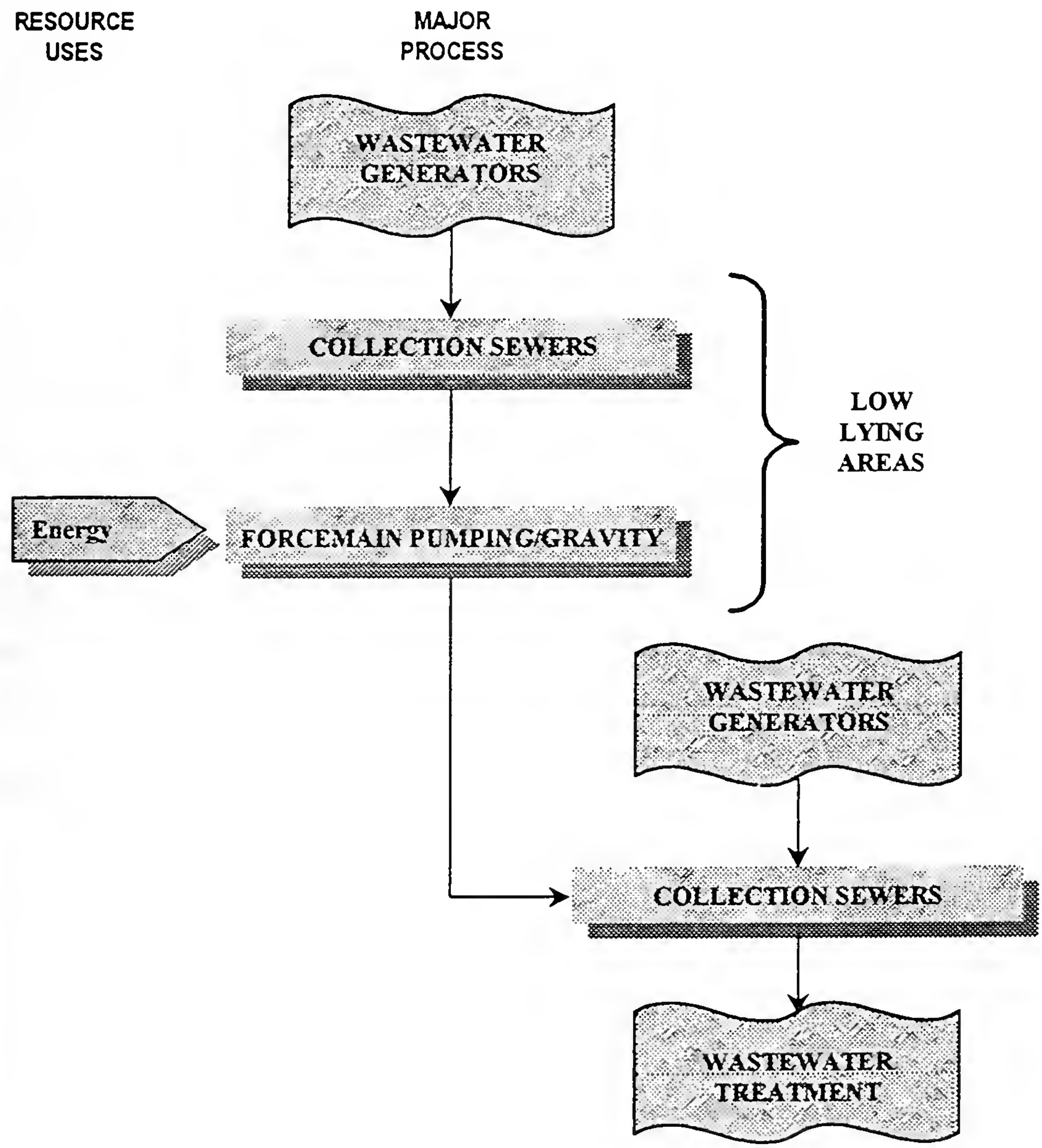


Figure 3.5
WASTEWATER COLLECTION



3.3 Utilities: Process and Plant

Typical utility requirements for the water and wastewater industry are summarized in Table 3.1.

Table 3.1
Typical Resource Applications

Resource	Resource Application	Applicable to
Water	Back washing, rinsing, foam control, chemical makeup, odor control	Water and Wastewater
Electricity	Pumps, blowers, conveyors, centrifuges, lights, HVAC, etc.	Water and Wastewater
Natural Gas	Space heating, hot water Incinerator fuel	Water and Wastewater Wastewater
Chemicals	Coagulation, precipitation, disinfection, oxidation, fluoridation, etc.	Water and Wastewater

The use of different resources varies significantly between processes and plants. The main reasons for this are:

- Variety in levels of treatment and processes employed.
- Variability in quality of the raw water, i.e. surface water or groundwater.
- Variability of receiving water quality and effluent requirements.
- Availability and cost of resources, such as natural gas supplies.

3.4 Process Related Residuals

As the level and complexity of treatment increases and facilities improve the effectiveness of residuals removal, the quantity of process related residuals often increase. The locations of residual production and emissions are identified in the generic flowsheets present in Figures 3.1 to 3.5. In Section 6, details on specific residuals for each process are described.

Typically, residuals produced in water and wastewater treatment facilities include:

Water Treatment Facilities

- Screenings
- Chemical sludge from settling and filter backwash

Wastewater Treatment Facilities

- Grit and screenings
- Biosolids
- Grease and scum
- Ash from incinerators

Water treatment plants typically have limited operations for processing residuals because of the small quantities of residuals produced. Typical management of water treatment residuals (i.e., chemical sludges) involves one or more of the following activities:

1. Pumping,

2a. Thickening - gravity thickening, centrifuge thickening or decanting basins,

2b. Chemical Conditioning,

2c. Dewatering – belt filter press, centrifuge, filter press or drying beds,

2d. Delivery to sewage treatment plants for further processing.

For wastewater treatment, screenings and grit are typically hauled off-site for disposal to a landfill. Wastewater biosolids, grease and scum, are typically stabilized by anaerobic or aerobic processes and disposed off-site via application to agricultural land or landfill. Biosolids treatment can include a thickening process upstream of stabilization to reduce the volume being stabilized. In addition, stabilized or unstabilized biosolids may be dewatered to reduce the volume of haulage. At a few larger Ontario wastewater treatment plants, incineration of biosolids is practiced. At those plants, dewatering upstream is used to reduce moisture content and residual ash is produced and disposed in ash ponds or at a landfill.

Anaerobic digestion of course produces methane gas which is employed as a supplemental fuel in cogeneration or other applications.

After processing, water and wastewater residual materials are generally disposed of in landfills or land applied if the concentrations of specific contaminants are at acceptable levels.

4. Resource Utilization

General resource use in the water and wastewater sector in Ontario is summarized in the following sections. Specific locations of resource use were identified in the generic process figures in Section 3 and are described in Section 6 under the conservation measures.

On a daily basis, 6 million cubic meters of potable water is delivered to Ontario consumers and an equivalent quantity of wastewater is treated and discharged back to the environment [15]. The value of the "product" provided by the water and wastewater treatment industry - water treated to the level to ensure either safe consumption or discharge - approaches $2 billion annually [16 and 17].

4.1 Energy

Energy usage in the water and wastewater sector can be a major portion of annual operation and maintenance costs. For this reason it is usually well monitored and documented by most plants across Ontario.

Table 4.1 provides a profile of energy use by the water and wastewater sector in Ontario using 1993 data. These data were provided in an Ontario Hydro report that surveyed water and wastewater facilities [6]. A total of 882 treatment plants, plus corresponding distribution/collection systems, were included in the survey. In 1993, an annual total of over 2 billion kWh was used by this sector. Also presented in the Ontario Hydro report [6] was the average annual electrical use of the five main energy uses in water and wastewater facilities. This information is presented in Tables 4.2 and 4.3 for water and wastewater facilities, respectively. The remaining energy consumption within water and wastewater facilities is used in other processes not identified in these tables and other miscellaneous requirements that can include lighting, heating, and ventilation.

4.2 Water

Water use within the water and wastewater sector has typically not been a major resource use or a major cost. For this reason, water use is not well documented in Ontario. Surveyed water use is presented in Section 5.

4.3 Chemicals

Chemicals addition to precess streams throughout water and wastewater facilities is practiced for a variety of functions. Furthermore, the type of chemicals used for a specific unit process can also vary from plant to plant and across Ontario. For example, disinfection during water treatment can be achieved using chlorine gas, sodium hypochlorite, chlorine dioxide or ozone. Disinfecting can also be achieved without the use of chemicals if processes such as ultraviolet light are used, although this represents increased energy use. For these reasons, ranges of chemical uses in water and wastewater facilities are typically reviewed by process.

TABLE 4.1
ENERGY USE PROFILE (1993 DATA)

SECTOR	NUMBER OF FACILITIES	ELECTRICITY USE (KWh/yr)	PEAK DEMAND (KW)
Water Treatment	468	730,716,000 (36%)	268,800 (59%)
Wastewater Treatment	414	787,624,000 (39%)	191,000 (41%)
Distribution Pumping Stations	-	363,663,000 (18%)	N/A
Remote Raw Sewage Pumping Stns	-	164,446,000 (8%)	N/A
TOTAL	**468**	**2,046,449,000 (100%)**	**459,800 (100%)**
TOTAL COST (@$0.07/KWh)	**882**	**$143,251,430**	**N/A**

TABLE 4.2
WATER TREATMENT PROCESS ENERGY PROFILE

PROCESS	FACILITY	ELECTRICITY USE (KWh/yr)
High Lift Pumping	Surface Water Supply, with Treatment	403,000,000
Low Lift Pumping	Surface Water Supply, with Treatment	143,803,000
Well Pumping	Groundwater Supply, no Treatment	77,168,000
Pumping to the Distribution System	Groundwater Supply, no Treatment	39,669,000
Flocculation	Surface Water Supply, with Treatment	8,697,000

TABLE 4.3
WASTEWATER TREATMENT PROCESS ENERGY PROFILE

PROCESS	FACILITY	ELECTRICITY USE (KWh/yr)
Aeration	Activated Sludge	332,928,000
Influent Pumping	Activated Sludge	83,416,000
Sludge Dewatering	Activated Sludge	53,820,000
Aeration	Extended Aeration	46,001,000
Effluent Pumping	Activated Sludge	44,877,000

5. SECTOR SURVEY

Water and wastewater survey questionnaires were sent to plants across Ontario requesting information regarding facility configuration and operation, resource usage and residual generation. A total of 667 water and 443 wastewater surveys were sent out. Survey replies were received from 116 water and 48 wastewater facilities, representing approximately 17% and 11% of Ontario's water and wastewater facilities, respectively.

The surveys provided valuable information on resource use in this sector; however, many were received with sections of the questionnaire incomplete. This factor together with the limited number of returned surveys restricts the ability to perform detailed process and metric benchmarking on this sector. The sector has been reviewed on general resource use with plants categorized using the following plant types:

Water

- Ground Water – No Treatment
- Groundwater – Treatment
- Surface Water – Disinfection Only
- Surface Water – Direct Filtration
- Surface Water – Conventional Treatment

Wastewater

- Primary Treatment
- Secondary Treatment
- Tertiary Treatment

Detailed variations in treatment processes have not been taken into consideration in this analysis. Specific process factors, such as nitrification requirements in wastewater plants, can significantly affect resource use trends. The following sections discuss resource use in Ontario. Survey figures are provided in Appendix B.

Users of this guide may be able to identify where their plant lies on these graphs for each resource use. Using reasonable judgement and knowledge of processes in use at a specific plant, operators should be able to identify potential areas for resource conservation. These graphs should not be used to evaluate plant performance.

Many survey responses did not provide annual average water or wastewater treated flows. In these cases, an assumed water consumption or wastewater generation rate of 450 Lpcd was used to convert serviced populations to treated flows.

5.1 Energy Use

This section provides a review of energy use in the water and wastewater sector in Ontario. Many of the responses provided the annual energy costs only. In these cases, an assumed charge of $0.07 / kWh was used to convert energy costs to energy use.

5.1.1 *Energy Use in Water Facilities*

Fifty two surveys provided information on annual energy use in water treatment plants. Information was obtained from 3 groundwater plants with no treatment, 21 groundwater plants with treatment, 4 surface water plants with disinfection only, 12 surface water plants with direct filtration and 12 surface water plants employing conventional treatment. Figures 5.1.1, 5.1.2 and 5.1.3 in Appendix B illustrate the total annual energy usage against the average annual water treated, shown at different scales for detailed definition.

An Ontario Hydro report [6] on municipal water and wastewater treatment facilities identifies average energy use rates in Ontario as: 104,000 kWh per ML/d for groundwater with no treatment; 76,000 kWh per ML/d for groundwater with treatment; and 75,000 kWh per ML/d for surface water with treatment. These rates are lower than the plotted information because the survey results take into consideration energy use in the distribution system as well. The Ontario Hydro report identifies overall energy use in distribution systems totaling approximately 50% of that used in treatment facilities. The additional 50% on the above numbers is much more compatible with the data presented in the graphs.

5.1.2 *Energy Use in Wastewater Facilities*

Thirty two surveys provided information on annual energy use in wastewater treatment plants. Information was obtained from 6 primary plants, 24 secondary plants and 2 tertiary plants. Figures 5.1.4, 5.1.5 and 5.1.6 in Appendix B illustrate the total annual energy usage against the average annual wastewater treated, shown at different scales for detailed definition.

The Ontario Hydro report [6] on municipal water and wastewater treatment facilities identifies average energy use rates in Ontario as: 51 kWh per M3/d for primary treatment; 74 to 412 kWh per M3/d for secondary treatment; and 246 kWh per M3/d for tertiary treatment. The ranges apply to secondary treatment varying from fixed film to extended aeration systems. These rates are slightly lower than the plotted information because the survey results take into consideration energy use in collection system pumping as well. The Ontario Hydro report identifies overall energy use in wastewater collection systems totaling approximately 20% of that used in treatment facilities. This additional 20% added to the above numbers makes them more compatible with the data presented in the graphs.

5.2 *Water Use*

This section provides a review of potable water use in the water and wastewater industry in Ontario.

5.2.1 *Water Use in Water Facilities*

Only 20 out of 116 surveys provided information on annual potable water use in water treatment plants. Information was obtained from 8 surface water plants with direct filtration and 12 surface water plants employing conventional treatment. Figures 5.2.1 and 5.2.2 in Appendix B illustrate the total potable water usage against the average annual water treated, shown at different scales for detailed definition.

An AWWA document "Water Quality and Treatment, 4th Edition" [14], states that typical water use in water treatment facilities is around 1 to 5% of the water treated. The survey information tends to be in the upper end of this range with the graphs showing points lying in the 4 to 5% range.

5.2.2 Water Use in Wastewater Facilities

15 surveys provided information on annual potable water use in wastewater treatment plants. Information was obtained from 5 primary plants, 8 secondary plants and 2 tertiary plants. Figures 5.2.3 and 5.2.4 in Appendix B illustrate the total annual potable water usage against the average annual wastewater treated, shown at different scales for detailed definition. Values presented in the Figures show typical water use is around 0.2% of water treated. The figures also illustrate that primary treatment tends to use more water than secondary and tertiary treatment.

5.3 Residue Generation

This section provides a review of residual sludge production in the water and wastewater industry in Ontario. Some of the survey responses did not provide residual waste production quantities. In these cases, the quantity of residuals produced was derived from the amount of alum used. Using an assumed cost of $0.20 per kg of Alum, sludge quantities were estimated for water plants. In cases where sludge volume instead of dry weight was provided, an assumed average of 2% solids was used.

5.3.1 Residue Generation in Water Facilities

21 surveys provided information on annual residual sludge production in water treatment plants. Information was obtained from 8 surface water plants with direct filtration and 13 surface water plants employing conventional treatment. Figures 5.3.1 and 5.3.2 in Appendix B illustrate the total residual sludge production against the average annual water treated, shown at different scales for detailed definition.

The AWWA report "Water Quality and Treatment, 4th Edition" [14], identifies typical impacts of source water quality on residue production as:

- Good-quality lake water 12-18 kg/ML
- Fair-quality lake water 18-30 kg/ML
- Average river water 24-36 kg/ML
- Poor-quality lake water 30-42 kg/ML
- Poor-quality river water 42-54 kg/ML

The information presented in the figures tends to lie in the good to average quality ranges identified above.

5.3.2 Residue Generation in Wastewater Facilities

Thirty two surveys provided information on annual residual production in wastewater treatment plants.Information was obtained from 6 primary plants, 24 secondary plants and 2 tertiary plants. Figures 5.3.3, 5.3.4 and 5.3.5 in Appendix B illustrate the total annual residual sludge production against the average annual wastewater treated, shown at different scales for detailed definition.

The MOE Design Guidelines identify typical ranges of sludge generation as 75 to 170 g/M^3 for primary treatment and 115 to 220 g/M^3 for secondary treatment. These ranges match the data provided in the surveys and presented in the figures.

5.4 Chemicals Use

This section provides a review of chemical use in the water and wastewater sector in Ontario. The surveys provided sufficient information on annual chemical use for chlorine, alum and polymer. Since there is a wide range of chemicals solutions used in the water and wastewater sector, chemical usage was compared using annual chemical costs. Comparisons with typical design criteria are difficult in this case because the conversions to dollars can not take into account the cost of the specific chemical and the extent of its use within a given facility.

Some of the survey responses provided only quantities of chemical use and no costs. In these cases, assumed costs of $2.00/kg for chlorine, $0.20/kg for Alum and $10.00/kg for polymer were used based on typical chemical costs from other surveys in similar quantity ranges.

5.4.1 Chemical Use in Water Facilities

Chlorine

Fifty three surveys provided information on annual chlorine use in water treatment plants. Information was obtained from 22 groundwater plants with treatment, 6 surface water plants with disinfection only, 12 surface water plants with direct filtration and 13 surface water plants employing conventional treatment. Figures 5.4.1, 5.4.2 and 5.4.3 in Appendix B illustrate the total annual chlorine cost against the average annual water treated, shown at different scales for detailed definition.

Typical ranges of chlorine use in water treatment ranges from 1 mg/L for good quality water supplies to 15 mg/L for poor quality river water.

Alum

Twenty one surveys provided information on annual alum use in water treatment plants. Information was obtained from 8 surface water plants with direct filtration and 13 surface water plants employing conventional treatment. Figures 5.4.4 and 5.4.5 in Appendix B illustrate the total annual alum cost against the average annual water treated, shown at different scales for detailed definition.

The AWWA report "Water Quality and Treatment, 4th Edition" [14], identifies typical alum requirements by varying water quality sources as:

• Good-quality lake water	36-54 kg/ML
• Fair-quality lake water	54-90 kg/ML
• Average river water	72-108 kg/ML
• Poor-quality lake water	90-126 kg/ML
• Poor-quality river water	126-162 kg/ML

Polymer

Seven surveys provided information on annual polymer use in water treatment plants. Information was obtained from 2 surface water plants with direct filtration and 5 surface water plants employing conventional treatment. Figure 5.4.6 in Appendix B illustrates the total annual polymer cost against the average annual water treated.

5.4.2 Chemicals Use in Wastewater Facilities

Chlorine

Thirt one surveys provided information on annual chlorine use in wastewater treatment plants. Information was obtained from 7 primary plants, 22 secondary plants and 2 tertiary plants. Figures 5.4.7, 5.4.8 and 5.4.9 in Appendix B illustrate the total annual chlorine cost against the average annual wastewater treated, shown at different scales for detailed definition.

Typical chlorine requirements identified in the MOE Design Guidelines are 3 to 20 mg/L for primary treatment, 2 to 9 mg/L for secondary treatment, and 1 to 6 mg/L for tertiary treatment.

Alum

Thirt three surveys provided information on annual alum use in wastewater treatment plants. Information was obtained from 8 primary plants, 23 secondary plants and 2 tertiary plants. Figures 5.4.10, 5.4.11 and 5.4.12 in Appendix B illustrate the total annual alum cost against the average annual wastewater treated, shown at different scales for detailed definition.

Typical alum requirements identified in the MOE Design Guidelines are 100 mg/L for primary treatment and 30 to 150 mg/L for secondary treatment.

Polymer

Fifteen surveys provided information on annual polymer use in wastewater treatment plants. Information was obtained from 7 primary plants and 8 secondary plants. Figures 5.4.13 and 5.4.14 in Appendix B illustrate the total annual polymer cost against the average annual wastewater treated, shown at different scales for detailed definition.

6. Generic Opportunities for Resource Conservation

This chapter reviews resource conservation measures. The review of resource efficiency and resultant cost savings focuses on processes, operations, equipment, utilities and buildings.

It is very important to consider the role that municipal management plays in the provision of water and wastewater services. Management is responsible for the operation and maintenance of these facilities and should provide full support and encouragement for these conservation and resource savings measures by:

- Establishing objectives and long term goals.
- Providing the means for staff to meet these goals through training, equipment, operating manuals and adequate staffing levels.
- Providing the financial assistance required for a detailed facility review and implementation of cost-effective resource savings measures.

The next sub-sections describe in detail measures applicable to each of the unit processes that were identified in Section 3. Each section provides a table with discussion to identify the resource savings measures. Identified opportunities are grouped as follows:

6.1 Generic Opportunities that impact multiple processes

6.2 Water Treatment

6.3 Water Distribution

6.4 Wastewater Treatment

6.5 Wastewater Collection

Plant operators may already be familiar with a number of the resource conservation opportunities. This guide is an attempt made by the MOE to review and summarize this information in a single package for the water and wastewater sector.

A technical/economic analysis and feasibility study should always be performed when considering resource conservation measures for implementation.

6.1 Generic Opportunities

A number of generic opportunities are available that impact both the water and wastewater industry. They are discussed in the sub-sections below and cross-referenced later in sub-sections 6.2, 6.3, 6.4 and 6.5.

6.1.1 Conservation of Water

Water conservation is a unique opportunity that impacts both the water and wastewater industries. This can be achieved at two levels: on the client or demand side through reduced consumption; and through reduced distribution system leakage and collection system inflow and infiltration. Both will reduce the quantity of water treated and distributed and the wastewater collected and treated. This results in an overall reduction in energy, chemical and

water use across the sector.

Implementing a water conservation program on the client or demand side requires capital investment and manpower to increase public awareness and execute programs. Although the initial costs can be high, the rewards are industry-wide with short payback periods. Payback periods are significantly reduced in systems where substantial infrastructure development is soon to be required. Successful water conservation will also help extend the life of treatment facilities, pumping stations and distribution/collection systems.

Since water conservation effects the entire industry, it is not cross-referenced in the following sub-sections (6.2 to 6.5).

Refer to success stories presented in Sections 9.2.24, 9.2.25, 9.2.26, 9.2.27, 9.2.28, 9.2.29, 9.2.30 and 9.2.33.

6.1.2 High Efficiency Motors/Variable Speed Drives

Many facilities use inefficient pump motors designed and installed years ago when system constraints and requirements were very different than today. Pump motor efficiencies are now much higher than what was available even ten years ago. As a result, significant energy savings can be realized by replacing the old motors in existing pumps. Using variable speed drive pumps, facilities can further eliminate the low efficiency that standard pumps experience over varying ranges of flow rates. Electricity savings identified in an Electric Power Research Institute (EPRI) report [4] for efficient motors range from 3 to 5 % and average payback periods range from 2 to 10 years. For adjustable speed drives, electrical energy savings range from 15 to 50 % with average payback periods of 1 to 8 years [4].

The most attractive payback occurs when existing motors need replacement and high efficiency motors or variable speed drives are appropriate for that application. Higher energy savings will also occur in facilities with high peak demand ratios that are pumping outside of the efficient range of the existing pumps.

Refer to success stories presented in Sections 9.2.1, 9.2.15 and 9.2.23.

6.1.3 Instrumentation Controls and Optimization

Instrumentation and controls are used in water and wastewater treatment facilities to ensure that process parameters are maintained within prescribed limits for an efficient operation. System performance and process conditions can be monitored through techniques such as particle counting, and efficient operation can be maintained using automated controls. Automating equipment can significantly reduce the use of energy, chemicals and water. Proper staff training support to calibrate and maintain instrumentation is critical to attain the benefits provided by Instrumentation and Control. Greater saving potentials may occur in facilities with high variability in water quality and/or flow because systems can adapt to clanging conditions and requirements. For example, in variable speed pumps applications, motor.speed may be modulated to match varying flow conditions.

Section 7 provides further details on specific applications. Refer to new technologies

presented in Sections 7.1 and 7.2.

6.1.4 *Off-Peak Operation*

During peak demand periods, energy demand and consumption charges are usually higher than during off-peak demand periods. Where possible, scheduling processes to operate during off-peak periods can significantly reduce energy cost. Shifting demands to off-peak periods requires operational changes only (i.e. no capital investment) and, as a result, payback can be immediate.

Although the energy cost is reduced, the amount of energy used during off-peak operation is not always reduced. Energy use reductions will only be achieved if the operating ranges of the process equipment are better suited for lower intensity/longer duration operations implemented by transferring operation to off-peak periods.

This technique may be applicable throughout a facility. The potential benefit varies with the type of process, available storage and the design of the specific facility under review. It should be noted that small plants do not necessarily have hydro demand meters or off-peak rates available. Therefore, this technique will not offer any savings in energy use or cost in these instances.

Refer to success stories presented in Section 9.2.32.

6.1.5 *Flow Measurement*

Accurate flow metering equipment for raw water flows, effluent and backwash water, and chemical dosing rates ensures optimized resource usage with significant effects on chemical usage, filter runs, backwashes and sludge production rates. For example, if flow measurement is inaccurate in a flow paced disinfection process, then unnecessary wastage of energy and chemical use can occur by over pumping and over dosing.

Since flow measurement is applicable through the treatment process where resources are used, it is not cross-referenced in the following sub-sections (6.2 to 6.5).

6.1.6 *Backup Generators*

Most treatment facilities have backup diesel generators to provide power during emergencies. They are not normally used except for testing and as a part of routine maintenance procedures. By operating these generators during peak periods, electrical energy use reductions and significant electrical energy cost savings can be achieved. Air quality requirements and the costs of fuel for backup generators may limit this application in some facilities, however, energy savings can be more than 20 percent, as identified in an EPRI report [4].

This scenario will only provide worthwhile savings for facilities with low generator operating costs and high peak demand ratios. Since this technique can be used to provide power throughout a treatment facility, it is not cross-referenced in Ssub-sections (6.2 to 6.5).

6.1.7 *Effluent Water Use*

In wastewater treatment facilities, potable water is used in a number of processes such as back washing, rinsing, chemical makeup, foam control and odor control. By replacing the use of potable water with treated effluent water, significant savings in water costs can be achieved.

Effluent water can be utilized wherever potable water is used in a wastewater treatment plant (except for drinking), therefore, this measure is not cross-referenced in the following sub-sections (6.2 to 6.5).

6.1.8 *Resource Efficient Equipment and Fixtures*

There are a number of energy and water efficient pieces of equipment and fixtures that are available for industry plants and homes. These same principles can be applied in the operation and maintenance of water and wastewater facility buildings. Some include:

- Light switch sensors in low traffic areas of plants that will reduce electricity use.
- Energy efficient light bulbs, especially in high traffic areas where lights are constantly running.
- Low flow fixtures in washrooms will reduce water usage.

These measures are general conservation opportunities for water and wastewater buildings and are not cross-referenced in the following sub-sections (6.2 to 6.5).

6.1.9 *Resource Costs*

There are a number of opportunities identified in this report for reducing the costs of resources, although the specific resource use is not reduced. Some examples include:

- Negotiating utility bills to reduce electrical energy and gas costs. For example, improving a plant's time-to-come-off-line during peak periods or in emergencies can assist in negotiating lower energy charge rates.
- Combining/separating utility bills between plants and pumping stations to reduce energy and gas costs. For example, combining plant energy costs with zone pumping station energy costs can reduce energy charge rates.
- Combining chemical purchasing with other plants or industries will increase shipment sizes and reduce unit costs. Refer to success stories presented in Section 9.2.13.

6.2 *Water Treatment Opportunities*

The specific opportunities available in the water treatment industry are described below for each process identified in Figures 3.1 and 3.2. Cross-references to **Section 6.1 – Generic Opportunities, Section 7 – New Technologies** and **Section 9.2 – Success Stories from Canadian and Foreign Sources** are presented with each opportunity where applicable.

6.2.1 Pumping

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy to operate pumps	None	1) Off-peak pumping	2) High-efficiency motors / variable speed drives 3) Pump capacity matching

1) *Off-Peak Pumping*

Refer to **Section 6.1.4 – Off-Peak Pumping**. Water can be pumped during periods where energy demand and consumption rates are lower by using available treated water storage. Significant energy cost savings are available in addition to potential energy use savings depending on pump sizes used and system demand curves.

2) *High-Efficiency Motors/Variable Speed Drives*

Refer to **Section 6.1.2 – High Efficiency Motors/Variable Speed Drives.**

3) *Pump Capacity Matching*

Many facilities do not have the available storage to apply off-peak pumping principles. In these cases, pumping is based on demand and the peak demands generally occur during on-peak energy demand hours. Often pumps supplying treated storage are operating outside of their efficient operating ranges to match distribution supply pumping. Significant energy losses are encountered when these pumps operate in the 70-80% efficiency range instead of their designed 90-95% efficiency range. This is especially significant during peak demand periods when the energy demand and consumption rates are highest.

High capital costs for replacing pumps can be offset by significant energy savings. A technical and economic feasibility should be performed on each individual case before a decision is made.

6.2.2 *Disinfection*

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemicals–chlorine gas; sodium hypochlorite; chlorine dioxide; and ammonia Water – to dilute chemical solutions and transport gaseous chemicals	None	1) Sodium hypochlorite	2) High velocity mixing & injecting systems 3) Ultra violet light 4) Membranes – nano & micro filtration 5) Clear well baffles

1) *Sodium Hypochlorite*

Sodium hypochlorite, unlike chlorine, is usually supplied in liquid form. This eliminates the need for water to dilute gas solutions to inject into the process streams. Costs and safe handling issues associated with the different chemicals need also to be considered. Sodium hypochlorite tends to increase pH levels which may also reduce the effectiveness of other treatment processes.

2) *High Velocity Mixing and Injecting*

High velocity mixing and injecting systems reduce water consumption through the direct injection of chlorine.

Refer to new technologies presented in Section 7.3.

3) *Ultra Violet light*

Ultra violet light disinfection, while using electrical energy, uses no chemical except in water supply applications where a residual disinfectant must be maintained in the distribution system. Trade-offs between increased energy usage and reduced chemical usage, together with other treatment benefits need investigation.

Refer to new technologies presented in Section 7.9.

4) *Membranes – Nano and Micro-Filtration*

Reduced chemical disinfectant use for coliform and virus inactivation can result from membrane filtration of *Giardia* cysts in order to achieve the required concentration-time (CT) requirements. Use of membranes often requires higher energy consumption, therefore a cost comparison should be conducted to select the most cost-effective means of disinfection.

5) *Clear Well Baffles*

The addition of baffles will improve plug flow and therefore contact time within the clear well. This will reduce chemical use while providing equal levels of disinfection in terms of concentration-time (CT) requirements.

6.2.3 Ion Exchange

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical - regeneration brine	Liquid brine residuals	1) Optimize regeneration frequency & duration	Ion exchange equipment

1) *Optimize Regeneration Frequency and Duration*

Chemical use reductions can be achieved by optimizing the amount of brine used to regenerate ion exchange beds. This can be achieved by controlling the regeneration step using current bed conditions; meeting minimum requirements of time, effluent concentration and head loss based on current bed conditions.

6.2.4 Aeration

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate blowers	none	eliminate air leaks in airlines	1) High efficiency blowers, variable speed drives 2) Alternate aeration devices

1) *High-Efficiency Blowers/Variable Speed Drives*

Refer to **Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives**.

2) *Alternate Aeration Devices*

Evaluation of multi-staged aeration, bubble size and surface aeration for specific treatment requirements can benefit volatile organic chemicals (VOCs), carbon dioxide, hydrogen sulphide and radon removals. In the case of hydrogen sulphide removal for example the downstream chlorine disinfection dose required would be reduced with the more efficient H_2S removal.

6.2.5 Filtration (Media)

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy- lift pumps. backwash pumps and air scour Chemical- filter aids Water- Back washing & surface wash	Liquid and solid residuals from Back washing	1) Effluent turbidity monitoring 2) Off-peak Back washing	3) Air/surface scour 4) Intermedia turbidity closed loop polymer feed control 5) Backwash water storage 6) Automatic continuous Back washing 7) Plastic media roughing filters

1) *Effluent Turbidity Monitoring*

   Significant reductions in energy, chemical and water use can be achieved by reducing the backwash frequency and duration. Refer to **Section 6.1.3 – Instrumentation and Control**. Monitoring and making adjustments based on backwash effluent turbidity instead of time can optimize the backwash duration. The backwash frequency is generally based on time, filtered water turbidity or head loss. The frequency can be optimized (reduced) by initiating backwashes based on filtered water turbidity and head loss.

   Monitoring turbidity peaks will also allow for reduced filter-to-waste durations which provides overall savings.

2) *Off-Peak Back washing*

   Refer to **Section 6.1.4 – Off-Peak Pumping**. By performing Back washing during off-peak hours, energy costs associated with operating pumps will be reduced due to lower unit charge rates. Although energy costs are reduced, there is no reduction in energy or water use.

3) *Air/Surface Scour*

   The scrubbing action provided by surface wash systems will improve the cleaning cycle by loosening attached floc and other entrapped solids from the filter media, and thereby reduce the water use in the backwash cycle.

4) Intermedia Turbidity Closed Loop Control

By retrofitting with an intermedia (between the anthracite and the sand) turbidity closed loop control to a filter aid polymer feed, extended filter run times can be effectively achieved. This will reduce the frequency of Back washing which in-turn will reduce energy and water use. Monitoring will also provide the opportunity to extend runs past peak energy cost periods. As mentioned above, this will not reduce energy use but energy cost reductions will be achieved.

5) Backwash Water Storage

By providing elevated Back washing storage, water for Back washing can be produced and pumped during low demand periods and stored for use during peak periods. Refer to **Section 6.1.4 – Off-Peak Pumping**. By pumping up to the elevated storage, the pressure head required during Back washing is available without pumping during the peak periods. Although this may not reduce energy use, significant energy cost savings can be achieved.

6) Automatic Continuous Back washing

This technology is used on specifically designed low head filters. Backwash water is continuously applied on small sections of the filter. The energy used is therefore low and continuous. For example, a small washwater pump mounted on a traveling bridge can replace large volume backwash pumps and air compressors used in conventional systems. Energy use reductions and significant energy cost reductions can be achieved.

7) Plastic Media Roughing Filters

Use of proprietary plastic media roughing filters can increase filter runs with consequent less backwash water and energy usage.

6.2.6 Filtration (Membrane)

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy- pumps and Back washing Chemical- filter cleaners Water- Back washing	Liquid and solid residuals	1) Optimize cleaning	2) Alternate uses

1) Optimize Cleaning

Optimization of membrane cleaning to maintain the flux and minimize the frequency and duration of the cleaning cycle can result in savings in both energy and chemicals. Maintaining the membrane flux by optimizing the cleaning cycle will also result in a reduction of energy used to maintain constant flux. A reduction in the quantity of cleaning chemical required will also result in chemical savings.

2) *Alternate Uses*

The use of membrane filtration in conjunction with other treatment needs should be considered. Membranes are continually under development to reduce operational energy needs. No coagulation chemical is used. Therefore no sludge disposal is required but reject water requires disposal. Back washing, if carried out, uses much less treated water.

Refer to new technologies presented in Section 7.7.

6.2.7 Screening

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy- operate mechanical screens Water- hydraulic jet cleaning	Solids residuals	1) Off-peak operation Cleaning frequency & duration reductions	

1) *Off-Peak Operation*

Refer to **Section 6.1.4 – Off-Peak Pumping**. By moving the operation to off-peak periods of the day, significant reductions in energy costs can be realized although energy use is not reduced. This will only be available in facilities with sufficient raw or treated water storage that can offset the operation of the screens.

2) *Cleaning Frequency and Duration Reductions*

Many facilities have scheduled routines for cleaning their mechanical screens. By monitoring the need for cleaning, the frequency of cleaning can be reduced or delayed to off-peak periods. Refer to **Section 6.1.3 – Instrumentation and Control**. This will reduce both energy use and energy costs. Furthermore, hydraulic jet cleaners are often operated for set periods of time. By monitoring the need for cleaning, spray use can be reduced which will reduce the amount of water used. In addition to water use reductions, the volume and water content of the residuals from screen cleaning can be reduced which will reduce the volume of residuals requiring final disposal.

6.2.8 Coagulation

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – coagulants & coagulant aids		1) Jar testing	2) Feed back control 3) Flow pacing 4) Optimize mixing 5) Optimize conditions

1) Jar Testing

Both overdosing and under dosing of coagulation chemicals can result in reduced treatment efficiency. Using jar settling tests to determine the appropriate dose for optimum process performance can result in chemical savings. Jar tests should be performed on a regular basis to adjust for raw water quality changes. Overdosing will also produce increased quantities of treatment residuals and consequent residual treatment energy requirements.

2) Feed Back Control

Feed back control of coagulant dose to accommodate for raw water quality changes may result in chemical saving depending on the range of variability of the raw water source. Refer to **Section 6.1.3 – Instrumentation and Control**.

3) Flow Pacing

Pacing the chemical dosing pumps to the water flow reduces the amount of adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. Optimized coagulant usage will result.

4) Optimize Mixing

By optimizing the mixing process during coagulation, a reduction in chemical use (coagulants) can be realized. This can be accomplished by diluting the coagulant before mixing or by retrofitting this process with in-line or mechanical mixers as appropriate to get rapid and uniform dispersion of the coagulant in the water to be treated. These techniques will increase water and energy use while reducing chemical use and must therefore, be investigated on a plant by plant basis.

Refer to new technologies presented in Section 7.2.

5) Optimize Conditions

By optimizing the conditions during coagulation, a reduction in chemical use (coagulants) can be realized. Refer to **Section 6.1.3 – Instrumentation and Control**. Conditions can be optimized for coagulation by adjusting the pH and alkalinity levels prior to this process or alternate chemical addition. Feed back control on these parameters to maintain the optimum pH would ensure optimum coagulation conditions are maintained.

Refer to success stories presented in Section 9.1.2

6.2.9 ***Sedimentation/Clarification*** *(Solids Separation by Dissolved Air Flotation)*

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate compressors	Liquid and solids residuals	eliminate air leaks in airlines	1) Optimized bubble size production

1) Optimized Bubble Size Production

By optimizing the bubble production size, significant reductions in air requirements are achieved. This results in reduced compressor capacity requirements which in-turn translates to reduced energy requirements. This opportunity is only available for flotation type clarification processes.

6.2.10 Ozonation

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate ozonator	Ozone	1) Ozone off-gas destruction	2) Air dryer/oxygen supply system

1) Ozone Off-Gas Destruction

Ozone use through optimized contact and increased percent ozone produced through air dryer and oxygen supply systems will result in a reduction in the ozone destruction requirements in the off-gases from contactors.

2) Air Dryer/Oxygen Supply System

By using dry air or oxygen as the feed gas to the ozone production unit, energy use per gram of ozone produced is reduced.

6.2.11 Dechlorination

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemicals – sulphur dioxide; sodium bisulphite; sodium sulphite		1) Optimize chlorine dose	2) Chlorine monitors with feedback control

1) Optimize Chlorine Dose

Facilities that over-chlorinate will require more chemical usage during the dechlorination step to reduce the free chlorine residual in the finished water. These facilities may realize chemical use savings, while still producing micro- biologically safe water, by reducing the chlorine dosages to the minimum requirements and at the same time reduce the amount of chemical required to dechlorinate. Refer to **Section 6.1.3 – Instrumentation and Control** and **Section 6.2.2** on clear well baffles.

2) Chlorine Monitors with Feedback Control

Control of chlorine dosage and dechlorination requirements through on-line chlorine residual monitors with feedback control are applicable to both drinking water and wastewater processing. Chemical savings can be achieved. Refer to **Section 6.1.3 –**

Instrumentation & Control.

6.2.12 Chemical Precipitation

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – lime	Liquid residuals	1) Optimize dose	2) Flow pacing

1) *Optimize Dose*

Optimizing the chemical dose can result in a reduction in chemical use and residual treatment and disposal. Refer to **Section 6.1.3 – Instrumentation and Control.**

2) *Flow Pacing*

Pacing the chemical dosing pumps to the water flow reduces the adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. A corresponding saving in chemical usage and residuals generation is achievable.

6.2.13 Sequestering

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – polyphosphate; sodium silicate	none	1) Optimize dose	2) Flow pacing

It means adding a conditioner to enhance the solubility of a chemical in solution.

1) *Optimize Dose*

Optimizing the chemical dose can result in a reduction in chemical use. Refer to **Section 6.1.3 – Instrumentation and Control.**

2) *Flow Pacing*

Pacing the chemical dosing pumps to the water flow reduces the adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. A corresponding saving in chemical usage is achievable.

6.2.14 Chemical Oxidation

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – chlorine; chlorine dioxide; potassium permanganate; or ozone		1) Optimize dose	2) Flow pacing

1) *Optimize Dose*

Optimizing the chemical dose can result in a reduction in chemical use. Refer to **Section 6.1.3 – Instrumentation and Control.**

2) *Flow Pacing*

Pacing the chemical dosing pumps to the water flow reduces the adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. A corresponding saving in chemical usage and residuals disposal needs is achievable.

6.2.15 Powdered Activated Carbon (PAC)

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Reagent – PAC	Liquid and solid residuals	1) Optimize dose and frequency of application	2) Flow pacing 3) GAC Caps

1) *Optimize Dose and Frequency of Application*

Optimizing the reagent dose can result in a reduction in its use and residuals produced. Refer to **Section 6.1.3 – Instrumentation and Control**. In addition, reduction of PAC produced treatment, storage and haulage requirements can be achieved. In the case of odor control, PAC dosing should be kept to periods of the year when there are odor problems and its use requirement monitored. For other uses, such as pesticide removal, raw water event/rainfall and parameter linkages can be used to ensure minimum time of application and optimized dosages.

2) *Flow Pacing*

Pacing the chemical dosing pumps to the water flow reduces the adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. A corresponding saving in chemical usage and residuals disposal needs is achievable.

3) Granular Active Carbon (GAC) Caps

Use of GAC (next Section 6.2.16) instead of PAC allows the facility to regenerate carbon instead of the typical disposal and replacement of carbon used with PAC.

6.2.16 Granular Activated Carbon (GAC)

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – GAC	Solid residuals	1) Optimize use	2) Consolidation of regeneration facilities

1) Optimize Use

Many facilities operate this process continually throughout the year for taste and odor control. In most cases, however, taste and odor control is normally required during specific times of the year. By implementing a monitoring program to only use the GAC filters during taste and odor events, extended life of the GAC filter bed can be achieved. Refer to **Section 6.1.3 – Instrumentation and Control**.

2) Consolidation of Regeneration Facilities

Consolidation of regeneration facilities between several communities can result in cost savings for regeneration and haulage (energy) requirements.

6.2.17 Fluoridation

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – hydrofluoroacetic acid; sodium silicofluoride	none	1) Optimize dose	2) Flow pacing

1) Optimize Dose

Optimizing the chemical dose through the use of a fluoride specific monitoring electrode can result in a reduction in chemical use and apparent cost savings. Refer to **Section 6.1.3 – Instrumentation and Control**. Water characteristics and physical conditions of the facility will influence the savings potential available.

2) Flow Pacing

Pacing the chemical dosing pumps to the water flow reduces the adjustments required to accommodate diurnal demand fluctuations. Refer to **Section 6.1.3 – Instrumentation and Control**. A corresponding saving in chemical usage and residuals disposal needs is achievable.

6.2.18 Water Treatment Residual

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – mechanical collectors in sedimentation / clarification and sludge dewatering	Solid and liquid residuals	1) Off-peak operation 2) Reduce produced solids 3) Optimize tank cleaning frequency and duration 4) Economic sludge disposal	5) Sludge vacuum systems

1) *Off-Peak Operation*

By moving the operation to off-peak periods of the day, significant reductions in energy costs can be realized although energy use is not reduced. Refer to **Section 6.1.4 – Off-Peak Pumping.**

2) *Reduce Produced Solids*

Minimizing the volume of sludge produced through optimal coagulant applications results in reduced solids processing, as well as haulage and disposal savings.

3) *Optimize Tank Cleaning Frequency and Duration*

Many facilities have scheduled routines for cleaning their tanks. By monitoring the need for cleaning, for example based on sludge depth, the frequency and duration of cleaning can be reduced, resulting in a reduction of water use. Refer to **Section 6.1.3 – Instrumentation and Control.**

4) *Economic Sludge Disposal*

Many communities have disposal options. By investigating the alternatives available in neighboring communities, the most cost-effective alternative can be identified and used.

5) *Sludge Vacuum Systems*

Retrofitting of sedimentation tank sludge removal facilities with vacuum operated sludge removal systems can enable economic sludge disposal to municipal sewers rather than on-site sludge conditioning and pump transfer.

6.3 Water Distribution Opportunities

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate pumps Water – consumer use, system maintenance and leakage		1) Optimize system operation 2) Off-peak pumping	3) High efficiency pumps/variable speed drives 4) Elevated storage 5) Leak detection 6) Pipe rehabilitation and replacement

1) *Optimize System Operation*

Many water distribution systems are operated using historical, and in many cases outdated, system parameters and settings. Operation of supply pumping stations, pressure reducing valves, booster-pumping stations, pressure zone boundaries and storage facilities should be reviewed and revised where appropriate to minimize wastage of resources. Resources saving potentials include energy to pump water and in some cases addition of chemicals for booster disinfection within the distribution system.

SCADA systems can be used to monitor system conditions and adjust performance to optimize resource use.

Utilizing system storage and demand peak shaving are two techniques that will reduce energy use during peak demand periods.

2) *Off-Peak Pumping*

Refer to **Section 6.1.4 – Off-Peak Pumping**. Using reservoirs and elevated storage, if available, water can be pumped at higher rates during low energy cost periods (i.e. late at night or very early in the morning). No reduction in overall energy use will result, however, significant energy cost savings can be achieved.

3) *High-Efficiency Pumps/Variable Speed Drives*

Refer to **Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives**.

4) *Elevated Storage*

Elevated storage that floats on the system can include elevated storage tanks or reservoirs located on high ground. Floating storage provides equalization supply during high demand periods, which usually coincide with high energy charge periods. Implementing elevated storage allows the system to utilize off-peak pumping concepts and reduce costs.

5) *Leak Detection*

Leakage within a distribution system can account for large quantities of water use within the system. This has an effect on system performance due to increased flow through the system and higher demand requirements from treatment plant pumping stations. By implementing leak detection programs, significant water losses can be reduced similar to that experienced in water conservation programs. Refer to **Section 6.1.1 – Water Conservation**. Lower water demands will also result in less wastewater generation.

6) *Pipe Rehabilitation and Replacement*

As water distribution systems begin to deteriorate, reduced flow capacities and pipe failures can be expected. These factors increase the pumping requirements throughout the system and, in-turn, increase energy used to operate pumps. By implementing a rehabilitation and replacement program, pumping requirements can be reduced which will equate to lower energy use.

6.4 Wastewater Treatment Opportunities

6.4.1 Pumping

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy - to operate pumps	None	1) Off-peak pumping	2) High-efficiency pumps/variable speed drives

1) Off-Peak Pumping

Refer to **Section 6.1.4 – Off-Peak Pumping.** These concepts will only be available for facilities with adequate storage to offset peak flows.

Refer to success stories presented in Sections 9.2.4.

2) High-Efficiency Pumps/Variable Speed Drives

Refer to **Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives**. Higher energy savings will occur in facilities with high peak demand ratios that are pumping outside of the efficient range of the existing pumps. Best results will be realized in wastewater pumping and aeration blowers.

6.4.2 Head works

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate blowers	Solid residuals	1) Optimize air supply to grit tanks	2) High-efficiency pumps / variable speed drives

1) Optimize Air Supply to Grit Tanks

Many plants operate with fixed air supply to grit tanks. By reducing the air supply to the minimum requirements, energy use reductions can be achieved through reduced use of blowers. Air requirements can be determined by monitoring the organic content of the grit.

2) High-Efficiency Pumps/Variable Speed Drives

Refer to **Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives**.

6.4.3 Primary Clarifiers

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – pumping of raw biosolids Chemical – coagulants and/or polymer	Solid and liquid residuals	1) Off-peak pumping 2) Reduce pre-precipitation chemicals for phosphorus removal 3) Improve chemical addition/mixing	

1) Off-Peak Pumping

Refer to **Section 6.1.4 – Off-Peak Pumping**. These concepts will only be available for facilities with adequate detention to offset peak flows.

2) Reduce Pre-Precipitation Chemicals for Phosphorus Removal

Chemicals can be added for phosphorus removal at either the primary or secondary level of treatment. Generally, chemicals are more efficient for phosphorus removal when added to secondary treatment, and chemical use savings can be achieved. Chemicals may still be used in primary treatment to enhance BOD removal in some facilities.

3) Improve Chemical Addition/Mixing

By improving the addition and mixing of chemicals at the point of addition, reduced chemical use will be achieved. There are many techniques and products available to improve chemical addition and mixing. They include in-line flash mixers or high velocity mixing systems.

Refer to new technologies presented in Section 7.3 and success stories presented in Sections 9.1.3.

6.4.4 Aeration

Resource Use	Residual Produced	Savings from Operational	Savings Requiring Capital Investment
Energy - to operate blowers Chemicals –coagulant and/or polymers	None	1) Minimize nitrification or oxygen supply need 2) Coagulant addition in primary treatment 3) On/off aeration 4) Optimize SRT 5) Pure Oxygen	6) Fine pore diffused air 7) High-efficiency blowers / variable output blower 8) Pre-denitrification with anoxic reactor 9) DO control instrumentation 10) Biological phosphorus or nutrient removal

1) *Minimize Nitrification or Oxygen Supply*

When nitrification is not required, controlling solids retention time and/or reducing DO levels will reduce oxygen requirements significantly. This reduces run time for blowers resulting in reduced energy use.

Refer to success stories presented in Sections 9.2.2.

2) *Coagulant Addition in Primary Treatment*

The addition of coagulant during primary treatment improves the removal of particulate before aeration. This in-turn reduces air requirements, which reduces blower operation and energy consumption. Although energy use is reduced, chemical use is increased during primary treatment and trade-offs must be investigated.

3) *On/Off Aeration*

By switching to an on/off operation, blowers can be operated for short periods of time (i.e. 30 minutes) and then shut down for equal or smaller periods of time. This reduces energy usage significantly. Blowers will need to be retrofitted with some form of ramp starting equipment to protect the blowers from the wear associated with an increased number of startups.

Following a successful demonstration [18], MOE and Water Technology International are currently engaged in on/off aeration pilot studies at a number of WWTPs in Ontario. Results of these studies should be available by the end of 1998.

Plants requiring denitrification should benefit from the conversion of nitrates to nitrate gas during the aeration off cycle.

4) *Optimize SRT*

By optimizing the Solids Retention Time (SRT), biomass production can be significantly reduced resulting in a reduction in energy use required for handling and disposal.

5) *Pure Oxygen*

Using pure oxygen instead of air improves oxygen transfer efficiency, which reduce the amount of gas blowers must pump. This results in a significant reduction in energy used.

Refer to success stories presented in Sections 9.3.33.

6) *Fine Pore Diffused Air*

Fine pore aeration systems produce smaller air bubbles which provide better oxygen transfer efficiency compared to coarse bubble systems. Improved oxygen transfer reduces the amount of air that blowers must supply and therefore reduces energy consumption by blowers. Energy savings potentials ranging from 9% to 40% can be achieved with fine pore systems [4].

Additional cleaning is sometimes required with fine pore systems to eliminate problems with clogging, however, the associated costs are minimal.

Refer to success stories presented in Sections 9.1.1, 9.2.6, 9.2.7, 9.2.8, 9.2.9, 9.2.10, 9.2.11, 9.2.12, 9.2.18, 9.2.19, 9.2.20 and 9.2.22.

7) *High-Efficiency Blowers/Variable Output Blowers*

Refer to **Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives**.

Refer to success stories presented in Sections 9.2.14, 9.2.17 and 9.2.21.

8) *Pre-Denitrification with Anoxic Reactor*

Anoxic reactors will recover bound oxygen, reducing the oxygen input requirement for blowers in downstream aeration basins. Although additional pumping to recirculate flow will be required, the significant reduction in blower use can provide for net energy savings.

9) *Dissolved Oxygen (DO) Control Instrumentation*

Excessive power use can be eliminated by monitoring DO within the aeration basins and manually or automatically controlling the number of blowers and air flow rates. Refer to **Section 6.1.3 – Instrumentation and Control.**

Refer to success stories presented in Sections 9.1.1, 9.2.3, 9.2.14, 9.2.16, 9.2.17, 9.2.18 and 9.2.21.

10) *Biological Phosphorus or Nutrient Removal*

By providing anaerobic/aerobic environments to increase the biological uptake of phosphorus, significant reductions in chemical use can be achieved. In some cases, the need for chemical input may be eliminated.

Refer to Section 8.5.

6.4.5 Secondary Clarifiers

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – return activated sludge (RAS) pumping		1) Optimize return sludge rates	

1) *Optimize return sludge rates*

By minimizing return sludge rates, a facility can maintain optimal sludge blanket levels in the secondary clarifier. This reduces RAS pumping rates (therefore energy use).

6.4.6 Filtration

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy- lift pumps and Back washing Chemical- filter cleaners Water- Back washing & surface scour	Liquid and solid residuals percent rejected	1) Off-peak Back washing	2) Back washing storage 3) Alternative filters

1) *Off-Peak Back washing*

   Refer to **Section 6.1.4 – Off-Peak Pumping**. By performing Back washing during off-peak hours, energy costs associated with operating pumps will be reduced due to lower unit charge rates. Although energy costs are reduced, there is no reduction in energy or water use. The ability to perform off-peak filter cleaning is influenced by the available storage and effluent concentrations.

2) *Back washing Storage*

   By providing elevated Back washing storage, water for Back washing processes can be produced and pumped during low demand periods and stored for use during peak periods. Refer to **Section 6.1.4 – Off-Peak Pumping**. By pumping up to the elevated storage, the pressure head required during Back washing is available without pumping during the peak periods. Although this may not reduce energy use, significant energy cost savings can be achieved.

3) *Alternative Filters*

   New high efficiency filter systems can provide significant energy savings over conventional filters, however, they may only be cost effective in plant expansions or new design.

6.4.7 Disinfection

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – chlorine Water – mixing gas solution	None	1) Optimize mixing 2) Automated dosing	

1) Optimize Mixing

By improving mixing, the effectiveness of the chemical addition is maintained with reduced chemical input. Some options for improving mixing include improved dilution of gases in water through high velocity mixing systems.

Refer to new technologies presented in Section 7.3.

2) Automated Dosing

Control of chemical addition to meet on-going requirements will reduce excessive chemical use. This will reduce chemical use during periods of the day when flows are lower or chemical requirements are not high. Refer to **Section 6.1.3 – Instrumentation and Control.**

6.4.8 Dechlorination

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – sulphur dioxide Water – mixing gas solution	None	1) Optimize mixing 2) Automated dosing	

1) Optimize Mixing

By improving mixing, the effectiveness of the chemical addition is maintained with reduced chemical input. Some options for improving mixing include dilution of gases in water (although water use is increased) and high velocity mixing systems.

2) Automated Dosing

Control of chemical addition to meet on-going requirements will reduce excessive chemical use. This will reduce chemical use during periods of the day when flows are lower or chemical requirements are not high. Refer to Section 6.1.3 – Instrumentation and Control.

6.4.9 Waste Activated Sludge (WAS) Thickening

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – polymer	Solids and liquids residuals	1) Automated dosing 2) Co-thickening in primary	3) Accelerated Dewatering

1) Automated Dosing

Control of chemical addition to meet on-going requirements will reduce excessive chemical use. This will reduce chemical use during periods of the day when flows are lower or chemical requirements are not high. Refer to Section 6.1.3 – Instrumentation and Control.

2) Co-Thickening in Primary

Co-thickening during primary treatment, unlike WAS thickening, can be achieved without the addition of chemicals. Therefore, by maximizing co-thickening in primary treatment, chemical use can be significantly reduced.

3) Accelerated Dewatering

Belt and drum filters provide improved dewatering rates and higher density sludge which may lower operating costs and sludge volumes requiring disposal .

Refer to success stories presented in Sections 9.2.33.

6.4.10 Anaerobic Digestion

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate blowers	Energy recovery (methane)	increase in capacity	1) Dual Digestion 2) Cogeneration

1) Dual Digestion

A dual digestion systems comprises two stage digestion process. In the first stage, injection of pure oxygen provides aerobic digestion accompanied by exothermic chemical and biological reactions. The second stage is conventional anaerobic digestion, which is accelerated by the previous WAS treatment in the first stage. This results in reduced heat requirements for anaerobic digestion and increased throughput rate.

Refer to Section *9.2.33 for a specific example.*

2) Cogeneration

Methane gas produced during the anaerobic destruction of organic matter can be utilized to generate electricity, operate equipment and/or heat buildings and digesters. Collection of gases is relatively easy and the gas can be used to operate equipment during peak periods to achieve maximum energy savings. Surplus power can also be sold to local utilities. Refer to success stories presented in Sections 9.1.3.

6.4.11 Dewatering

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate blowers Chemicals – polymers	Solids residuals	1) Optimize mixing	2) High efficiency pumps/ variable speed drives

1) Optimize Mixing

By improving mixing, the effectiveness of the chemical addition is maintained with reduced chemical input.

Refer to success stories presented in Sections 9.1.3.

2) High-Efficiency Pumps/Variable Speed Drives

Refer to Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives.

6.4.12 Incineration

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemicals – oil or natural gas	Solids residuals	1) Optimize dewatering 2) Minimize shut downs 3) Maintain consistent solids inflow	4) Land application

1) Optimize Dewatering

By improving the efficiency of dewatering, less volume of residuals will require processing in incineration. In addition to lower volumes, lower moisture concentrations burn more efficiently and require less auxiliary fuel (natural gas) input.

2) Minimize Shut Downs

The major use of resources in incineration occurs during start-up when large quantities of fuel are required. Afterwards, biosolids residuals provide the majority of the fuel requirements with minimal outside fuel resources used to maintain temperatures. By minimizing shut downs, the large quantities of fuel required for start up can be avoided.

3) Maintain Consistent Solids Inflow

By maintaining consistent solids inflow, a consistent fuel is provided for burning. When solids inflow varies, additional auxiliary fuel is required to maintain burning temperatures.

4) Land Application

Biosolids can be applied to agricultural land applications and, therefore, fewer quantities require incineration.

6.4.13 Odor Control

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Chemical – ozone or chlorine Water – for cooling	None	1) Optimize mixing	2) Cooling system that reuses water

1) Optimize Mixing

By improving mixing, the effectiveness of the odor control is maintained with reduced chemical input.

2) Cooling System that Reuses Water

Large quantities of water can be used for cooling processes (with ozonator odor control applications), which are disposed of after use. By retrofitting to a system that reuses water as part of the cooling process, significant water use savings can be achieved.

Refer to success stories presented in Sections 9.1.3.

6.5 Wastewater Collection Opportunities

Resource Use	Residual Produced	Savings from Operational Changes	Savings Requiring Capital Investment
Energy – to operate pumps		1) Off-peak pumping 2) Optimize operation	3) High-efficiency pumps / variable speed drives 4) I/I programs

1) *Off-Peak Pumping*

Refer to Section 6.1.4 – Off-Peak Pumping. Detention storage is necessary to modify the pumping schedules during high peak periods.

2) *Optimize Operation*

Operation of pumping stations can be optimized to reduce energy use. Options include the use of SCADA systems to monitor system conditions and adjust performance to optimize energy use. Utilizing system storage and demand peak sharing are two techniques that will reduce energy use during peak periods.

3) *High-Efficiency Pumps/Variable Speed Drives*

Refer to Section 6.1.2 – High Efficiency Pumps/Variable Speed Drives.

4) *Inflow and Infiltration Programs*

Inflow and Infiltration (I/I) can be major sources of flow in wastewater systems. This has an effect on system performance due to increased flow through the system and higher demand requirements from pumping stations. By implementing I/I programs, wastewater flows requiring treatment can be significantly reduced resulting in lower treatment requirements and consequent resource (chemical and energy) savings.

7. INNOVATIVE TECHNOLOGIES

In this section, a number of technologies that can effect chemical, energy and water use and residuals production are discussed. These technologies are not necessarily new, but may not be generally applied in Ontario and merit consideration. A selection of such technologies are briefly described below in the following sub-sections and have been cross-referenced in the resource conservation opportunities in Section 6.

The application of new technologies in water and wastewater treatment are identified as (Water), (Wastewater) or (Common) to both.

7.1 Specific Parameter On-line Measurement

Optimization of processes through the use of on-line measurement and feedback control loops can significantly reduce the amount of chemical, energy and water use as well as reduce the production of waste residuals requiring treatment and disposal.

Control applications include:

- On-line chlorine residual monitors with feedback control are applicable to both water and wastewater treatment to control chlorine dosages and dechlorination requirements. (Common)
- Aeration rates in wastewater treatment controlled through dissolved oxygen probes. (Wastewater)
- Ozone residual analyzers controlling ozone addition and hence production needs; this technology can apply to water and wastewater treatment. (Common)
- Fluoride application to water treatment through specific ion electrode monitors with feedback to dosing pumps. (Water)
- In water treatment, interface turbidity analyzers in filters (between the top anthracite layer and the sand) to control chemical filter aid application and extend filter run times. (Water)
- On-line ammonia analyzers to control chlorine application in water treatment to achieve the desired residual disinfectant. (Water)
- pH electrodes to control coagulation processes and corrosion control chemical application in water treatment. (Water)
- On-line phosphorus analyzers to optimize phosphorus precipitation chemical dosages for wastewater treatment. (Wastewater)
- Sludge conditioning chemical control through on-line viscosity measurement with signal feedback can apply to both water and wastewater residuals dewatering processes. (Wastewater)

7.2 *Streaming Current Monitors - SCM (Water)*

An SCM measures colloidal charge immediately after coagulant and coagulant aid addition to ensure charge neutralization (particle destabilization) is occurring. A signal is generated permitting closed-loop control of coagulant dosage. This will eliminate chemical overdosing or under dosing and provide optimal treatment.

Chemical savings averaging around 25% can be achieved. In addition, with fewer solids being produced, filter runs will be optimized requiring fewer backwashes and saving water and backwash pumping energy. Less sludge will be produced with consequent savings in sludge processing and disposal energy costs.

Stabilization of the distributed water after treatment for corrosion control generally requires application of chemicals to raise pH or provide additional alkalinity. The lower coagulant chemicals applied will subsequently reduce the post-treatment chemical requirement.

7.3 *High Velocity Mixing Systems (Common)*

High Velocity Mixing Systems (HVMS) are a newly developed submersible induction system and can be used in both water and wastewater treatment. The systems replace the injector, injector pump, diffuser, mechanical mixer, filter and strainer of traditional induction systems. HVMS's also eliminate the need for potable water required for chlorination and dechlorination processes. These systems operate with a propeller that injects the chemicals into the process stream at high velocities for better mixing.

As a result of the better mixing achieved with HVMS's, significant chemical use reductions can be achieved. Energy savings are also realized for two reasons, fewer chemicals require pumping into the process and the HVMS is one mechanical unit requiring energy rather than a separate pump, injector and mixer.

7.4 *Bacterial Regrowth Monitor (Water)*

Bacterial regrowth potential can be monitored through simulation of flow and surface conditions in distribution systems. An annular reactor can be installed in a side stream of the treated water and removable slides (simulating pipes, etc.) can be removed and analyzed for corrosion, biomass growth and deposition. These parameters are affected by treated water quality, which is determined by treatment conditions and processes. Early warning of potential regrowth or corrosion, or the reduction in these issues as a result of treatment changes, can be determined. Corrosion, deposition and biological growth on pipe surfaces can significantly affect pumping energy requirements.

7.5 *Biological Phosphorus Removal (Wastewater)*

Biological phosphorus removal is practiced in wastewater facilities in many countries around the world, however, there are currently no full-scale installations in Ontario. This technology involves subjecting biomass to anaerobic (no oxygen or nitrate) and aerobic environments. These conditions result in a biological uptake of phosphorus that exceeds normal biological synthesis requirements.

Biological phosphorus can significantly reduce or eliminate the chemical requirements for

phosphorus removal. Reduced chemical usage will also lead to reduced sludge production, which in-turn reduces the energy use associated with handling and disposing of sludge.

7.6 *Autothermal Thermophilic Aerobic Digestion (Wastewater)*

Autothermal thermophilic aerobic digestion (ATAD) is a modification of conventional aerobic digestion in wastewater treatment. ATAD processes operate at temperatures in the thermophilic zone of biological activity, which speeds up the digestion process. Operating temperatures in this range typically inhibit nitrification. The shorter digestion periods and typical reduced nitrification levels reduce aeration requirements. This translates into significant energy savings.

7.7 *Membrane Bioreactors (Wastewater)*

Membrane bioreactors involve using membranes to filter out particulate matter that is normally removed during secondary clarification. This eliminates secondary clarifier and requirements of pumping return activated sludge. Furthermore, these reactors generally allow for elevated solids concentrations, which reduces aeration tank sizes and potentially reduces aeration requirements. As a result, significant energy savings can be achieved through elimination of return sludge pumping and the potential reduction in aeration requirements.

7.8 *Raw Water Control/Reservoir Mixing (Water)*

An important water supply philosophy, which can save on resource use for treatment, is to obtain raw water from the best possible source and to protect that source from contamination. The concept involves the institution of source water controls ranging from watershed protection programs to reservoir management, including specific extraction and impoundment of raw water from river sources. Using this approach, it is possible to reduce treatment chemical requirements for coagulation, disinfection and taste and odor control. This extends filter run lengths, reduces backwash water needs and reduces sludge production and disposal requirements, which in-turn reduce both energy and water usage.

7.9 *Alternate Disinfection (Common)*

Ultraviolet light disinfection provides effective levels of treatment without the use of chemicals. It should be noted however, that energy use is increased and chemical addition is required later during treatment to provide a residual for distribution in water treatment. Trade-offs regarding energy and reduced chemical usage, together with other treatment benefits need investigation.

7.10 *Membrane Filtration (Water)*

A reduced chemical disinfectant requirement for coliform and virus inactivation can result from membrane filtration (nano and micro) of *Giardia* cysts. The concentration-time (CT) requirements for coliform and viruses require significantly less chemical disinfectant than *Giardia* cyst inactivation.

7.11 *Membrane Aeration (Wastewater)*

The use of membranes to diffuse molecular oxygen from air into wastewater can provide very

efficient transfer of oxygen, resulting in significant energy use reductions.

7.12 *Biological Nitrogen Removal (Wastewater)*

Biological nitrogen removal is practiced in wastewater facilities in many countries around the world, however, there are currently no full-scale installations in Ontario. This technology involves subjecting biomass to anoxic and aerobic environments. Biological nitrogen removal can significantly reduce oxygen requirements and therefore reduce energy use through reduced blower operation.

7.13 *Zebra Mussel Control (Water)*

Although alternate technologies (other than chlorine) for zebra mussel control are considered temporary measures, they can result in resource conservation. For example, Molluscicides with National Sanitation Foundation (NSF) approvals kill zebra mussels in the larval stage and avoid the issues with adult dead mussel removals and potential taste and odor problems.

In terms of resource use savings, many of these Molluscicides will act as larval killers and improve water clarification. This will reduce the requirement for coagulation chemical and consequently reduce sludge production and disposal. Also there will be no "extra" trihalomethane production.

7.14 *Outfall Micro-Turbines (Wastewater)*

The introduction of electrical micro-turbines on wastewater outfalls has started to emerge in the United States. The slow, constant flow from outfalls produces electrical power that can be reused in the treatment facility. Small treatment facilities may find that enough energy is generated in these turbines to completely meet their energy requirements. Depending on the location of the outfall and the receiving water, turbines may not operate throughout the year due to high water levels.

7.15 *Oxidation Reduction Potential - ORP (Common)*

During chlorination and dechlorination processes, different disinfectants have different disinfecting powers, because of different oxidation potentials. ORP can be used to improve disinfection strength when varying chlorine residuals can occur and reduce the quantities of chemical addition. Use of this technology is currently limited because of the lack of reliable monitoring instrumentation and the varying levels of ORPs in different wastewater.

7.16 *Other Technologies*

Other technologies, some of which are commonly used in other industries, which merit consideration include:

- Heat pumps in wastewater facilities to remove heat from effluent flow and supplement heating of buildings. (Wastewater)

- Air to water heat exchangers on blower discharges in wastewater facilities can be used to recover heat for heating of buildings. (Wastewater)

- Heat exchangers on ventilation air exhausts can provide significant reductions in heater energy requirements. (Common)
- Duct and fan system to circulate warm air in blower rooms to heat small areas of a plant. (Common)
- Solar walls to preheat air before it enters and is ventilated through a building. (Common)
- Wind driven turbines to generate electricity or operate mixing equipment. (Common)
- On/Off Aeration systems, as discussed in **Section 6.4.4**. (Wastewater)
- Pure Oxygen use in aeration systems, as discussed in **Section 6.4.4**. (Wastewater)
- Dual Digestion systems, as discussed in **Section 6.4.10**. (Wastewater)
- Belt and Drum filters for WAS thickening and dewatering, as discussed in **Section 6.4.9**. (Wastewater)

8. Priorities and Implementation

The potential for resource conservation is substantial in most water and wastewater plants across Ontario. Many plant operators through there own initiative have assessed conservation opportunities and implemented low or no cost strategies on a case by case basis. It should be noted that the highest potential for resource conservation occurs during the design of these facilities. If plants are initially designed with resource conservation in mind, savings are much easier to achieve.

This section describes an approach for reviewing a facility and investigating, evaluating and implementing resource conservation measures and cost saving opportunities.

8.1 Implementation Strategy

It is of paramount importance for the potential success of a resource conservation project, that the project champion must obtain commitment and "buy-in" from top management. The justification for the project should be based on a comprehensive technical and economic evaluation. In the context of budget cutbacks and reduced funding for capital projects in the water and wastewater treatment sector, municipal owners and operators will have to address the issue of how to pay for proposed improvements. The decision makers on capital expenditures need to be convinced that such improvements are cost-effective investments. Resource Service companies should be approached as partners for alterative sources of funding and implementation strategies. This may be a win-win situation; the resource service companies get an opportunity to enter the MW&WW treatment market.

In order to evaluate potential resource savings in a systematic manner, reports were produced by the WEF [3] and EPRI [4] each outlining energy programs. These concepts have been used to develop a Management Program to review higher-end opportunities and promote conservation measures. A Management Program includes the following steps:

1. Data Collection
2. Data Analysis
3. Management Plan Development
4. Management Plan Implementation
5. Management Plan Monitoring

These five steps are discussed in detail in the following sections.

8.1.1 Data Collection

The initial step in any program of this nature is to perform an audit of the facility. This would involve collection of data from energy, chemical and water use equipment in the plant including pumps, motors, chemical injectors, backwash sprayers, cooling systems and other equipment. The information collected should include:

- Related equipment, such as a chemical injector associated with a flow meter.
- Operating and billing records to determine frequency of use of equipment.
- Usage records from local utilities, such as hydro and gas.
- Equipment ratings measured by qualified professionals, such as power draw on major pieces of equipment.
- Operations information including effluent flows, returned activated sludge flows, BOD data, blower supply, chemical usage, back washing frequencies and durations, etc.
- Energy, chemical and water usage data.
- Residual production and treatment data.
- Operator log information should be reviewed and revised if additional data need to be recorded.
- Other pertinent information.

As part of this step, an understanding of resource use profile and associated cost needs to be developed, including hydro, gas and water bills, and chemical purchasing. Items such as power factor charges on hydro bills need to be understood to identify potential resource and cost savings opportunities.

Planning objectives and goals of the management program should also be identified and reviewed. These objectives may need to be revised as the program proceeds and specific conditions are discovered in order to develop reasonable and achievable goals.

8.1.2 Data Analysis

Using the information collected, the next step is to proceed to analyze the facility. The first step is to estimate energy, chemical and water usage and residue production for a given period, typically the last two to five years depending on the data available. Where information is suspect or missing, attempts should be made to measure or verify this information. Once a realistic estimate of the facilities resource usage has been developed, the facility can be compared with data for similar facilities. This comparison will identify areas where potential savings can be achieved and where efforts for resource conservation should be focused.

Pumps and blowers are major users of energy within the water and wastewater sector. For this reason, a comprehensive and detailed review and evaluation of performance and efficiency of pumping and air blowing equipment and controls should be conduct. The cooperation of the manufacturer or the supplier of the equipment should be sought if necessary. They can help with documentation and performance testing. Regular monitoring programs for pump energy efficiencies should be implemented if not already part of plant operation and maintenance programs.

8.1.3 Management Plan Development

The next step involves examining alternatives that will achieve the goals identified at the beginning of the program. First, the relative magnitude of resource use must be determined within processes of the plant.

Next, alternatives for meeting goals and objectives must be identified for each process. Resource conservation measures are identified in Section 6 and can be reviewed on a process by process basis. Now the list of alternatives needs to be screened at various levels of complexity. A technical/economic analysis and feasibility study should be undertaken to evaluate all conservation projects considered. For example, reviewing replacement of pump involves a comparison of capital cost versus savings while the revising of pumping schedules may require detailed modeling simulations. Selection of feasible alternatives can be made that meet the goals set out at the beginning of the program.

In addition to conservation measures, the program can then be designed to include incentive structures, implementation plans, marketing plans, quality assurance/control procedures and training. Throughout this planning exercise, it is necessary to consider customer needs, quality and environmental requirements along with program objectives.

8.1.4 Management Plan Implementation

Although Management Plans will vary significantly from plant to plant, the critical stage is the implementation. The plant audit and review have identified areas for potential resource use savings and the Management Program has been developed from a review of multiple alternatives and techniques.

The program will in many cases introduce new technologies and strategies into a plant and may require pilot scale testing prior to full scale implementation. Special attention is needed when interpreting results of pilot scale testing to ensure a true understanding is developed of the resource usage reduction potential for the full scale implementation.

8.1.5 Management Plan Monitoring

Monitoring of the program and evaluating results is critical to understand the effectiveness of the Management Program. In many cases, pilot-scale or phased implementation of the program is performed due to limited budgets or skepticism regarding projected results. Particularly in these cases, monitoring is very important to justify additional measures based on the cost-effectiveness of the initial program. Monitoring will also provide the information necessary to adjust or modify the Management Program if possible to achieve better results.

Prior to any monitoring program, the facility must ensure that information on the plants performance and resource usage is available for comparison. If this information was not available and not used in the selection of conservation measures, it should be collected prior to implementation of the Management Program.

After the Management Program has been monitored, resource usage should finally be compared with the data for similar facilities. If the conservation measure does not reduce the

resource usage to the goals and objections identified early in the program, then additional review of the implementation and possible revisions should be considered.

Currently, the amount of information available in Ontario on conservation opportunities is limited due to the lack of monitoring performed in treatment facilities. Increased monitoring and the availability of such information in the future will help to promote conservation in this industry.

8.2 Summary Checklist of Resource Conservation Measures

Readers can review conservation opportunities and new technologies in detail in Sections 6 and 7, respectively. Typically, the conservation measures that provide the highest potential for resource use and/or cost savings are identified below. These generic areas should be focused on when considering a resource conservation program.

Energy Conservation

- High efficiency motors and/or variable speed drives which can offer average annual savings of 3 to 5 % and 15 to 50 %, respectively.
- Instrumentation and controls to monitor on-going conditions and adjust system performance, particularly in the operation of pumps and blowers.
- High efficiency aeration systems, such as fine pore diffused air systems, which can offer savings ranging from 9 to 40 %.
- Optimized scheduling and off-peak operation of pumping facilities in water distribution systems.
- Negotiating energy charges and rate structures with local utilities.

Water Conservation

- Reduce filter Back washing frequencies and durations to provide significant water use savings.
- Repair and eliminate leaks in water lines.
- Always follow a rigorous maintenance program in the whole plant.
- Use effluent water instead of potable water for foam control, chemical makeup, chemical transport and other uses in water and wastewater facilities.

Chemical Conservation

- Instrumentation and controls to monitor on-going conditions and adjust chemical addition, including flow pacing and particle counting.
- Evaluate alternative chemicals to maximize performance and reduce their use.
- Evaluate bulk purchasing opportunities.

8.3 *Priority Items and Selection Criteria*

The success of a Management Program involves consideration of a number of factors with respect to the facility under review. Most factors are inter-related and cannot be considered independently. Priority items and important selection criteria that must be considered when developing a Management Program, as identified in a recent WEF manual [3], are:

1. *Ranking of Project Objectives* - The facility management must prioritize project objectives including maximizing resource conservation, maximizing financial benefits or servicing system loads.

2. *Design Factors* – The design selection process is influenced by the system size, mode of operation, anticipated resource usage and future changes in flows and loadings. Design for resource conservation and environmental protection.

3. *Operational Factors* – Factors include staff requirements, training, scheduling and equipment maintenance.

4. *Siting Factors* – For planned self-generation projects, facility siting is influenced by locations of fuel sources and service loads, plant operations, service areas, availability of land, and other economic factors.

5. *Economic Factors* - Factors include current and projected resource use and costs, capital and operation/maintenance costs, site costs, potential savings, budgets, tax benefits, etc.

6. *Environmental Factors* – Factors vary by location and are subject to municipal, provincial and federal regulations and by-laws. Prior to program design, local agencies should be consulted for up-to-date constraints for the program.

8.4 *Ontario Suppliers of Equipment*

In order to implement many of the conservation measures identified in this report, the purchasing of equipment and/or the need for professional service may be required. A list of equipment suppliers and service companies is provided in Appendix C for reference and information only. This list was obtained from the Ontario Water Works Equipment Association and the Ontario Pollution Control Equipment Association listings.

The MOE and XCG Consultants Ltd. do not necessarily endorse these companies and there are other suppliers with good credentials that are not affiliated with these associations. It is recommended that when equipment or services are required, that plant staff also contact local consultants and municipal staff.

9. SUCCESSFUL RESOURCE CONSERVATION APPLICATIONS

Success stories are intended to provide examples of the extent of resource savings that many plants have been able to achieve in water and wastewater treatment. The first section presents detailed descriptions of four recent success stories. The second section provides short descriptions of and reported savings from a number of successful conservation measure in Canada and other countries.

Many facilities in Ontario and across Canada have implemented conservation measures over the past decade in response to the need for more efficient resource use. However, some of these facilities have not properly documented quantitative evaluation of resource use before and after and other benefits of the improvement made. It is hoped that, in the future, facilities will begin to monitor their investments and savings to help promote these efforts.

The success stories identified in this section have been cross-referenced in Section 6 - Generic Opportunities for Resource Conservation, Pollution Prevention and Source Reduction. Under the descriptions for each of the savings opportunities, the last paragraph cross-references this section where applicable.

9.1 Detailed Success Stories

9.1.1 City of Chatham Water Pollution Control Plant (WPCP)

The aeration system at the Chatham WPCP includes two, three-pass, spiral flow aeration tanks with a total volume of 6,343 cubic meters. Five positive displacement blowers supply the air. Three blowers have capacities of 4,250 M^3/hr each, the remaining two blowers are 5,097M^3/hr each.

Chatham recently implemented two energy savings measures as follows:

1. Dissolved Oxygen Monitors and On-Line Dissolved Oxygen Control System
2. Fine-Pore Aeration System

Dissolved Oxygen Monitor

Original operation of the plant involved leaving one of the blowers in operation after the plant staff finished their shift. The plant installed a dissolved oxygen monitor and control system at a cost of $2,900. The on-line control system operated the blowers to meet DO demands. The majority of the savings occurred by controlling the operation of the blowers after hours when they were unmanned.

In the following year, the electrical energy savings from reduced use of the blowers resulted in approximately a $50,000 reduction in energy costs, effectively yielding an immediate payback.

Fine-Pore Aeration System

The plant replaced the original carborundum tubular diffusers with ceramic dome fine bubble diffusers mounted on PVC piping with in situ hydrogen chloride gas cleaning. The cost for equipment and installation was $366,000, of which approximately 47% was provided by MOE and Ontario Hydro grants.

In situ gas cleaning allowed the diffusers to be maintained while in operation and guarantee savings in energy use and maintenance of the aeration system. The expected savings from the in-situ cleaning were $5,000 per year for chemicals and labor.

The improved oxygen efficiency transfer allowed the plant to shut down its fifth blower that had previously run constantly. The calculated demand reduction and consumption savings were estimated to be 116.2 kW and 681,400 kWhrs/yr, respectively. This equates to an annual cost savings of approximately $39,400.

9.1.2 Kentucky-American Water Company, City of Lexington WTP

Kentucky-American Water Company carried out a full-scale plant performance evaluation at the City of Lexington WTP. In this evaluation, their current chemical used for coagulation, ferric chloride, was replaced with an aluminum based coagulant, SternPAC. The main areas where resource conservation could be achieved were identified as the coagulant usage, lime usage, solids residuals disposal required and filter backwash water usage.

During the evaluation, the following comparisons were made:

During Ferric Chloride Application

- Chemical use — 260 lbs /MG water
- Cost of chemical — $29.90 /MG water
- Sludge residual production — 2080 lbs of 10% solids sludge/MG water
- Cost of sludge disposal — $ 6.24 /MG water
- Additional chemical use (lime) — 105 lbs /MG water
- Cost of lime (additional chemical) — $ 3.72 /MG water
- Water Usage (Back washing) — 840,000 gal/day

SternPAC Program

- Chemical use — 250 lbs /MG water
- Cost of chemical — $42.50 /MG water
- Sludge residual production — 395 lbs of 10% solids sludge/MG water
- Cost of sludge disposal — $ 1.19 /MG water
- Water Usage (Back washing) — 700,000 gal/day

As identified above, there is an insignificant reduction in chemical use (approximately 115 lbs of Ferric and lime) and the actual chemical cost increases. The main savings are in the liquid and solids residuals (sludge) production where an 81% saving in disposal costs was identified. A significant water usage savings of 140,000 gallons per day from reduced Back washing requirements was also identified.

9.1.3 Regional Municipality of Ottawa-Carleton, Ottawa-Carleton WWTP

In late 1992 the Regional Municipality of Ottawa-Carleton (RMOC) commissioned a wastewater treatment plant expansion that resulted in the operation of a secondary treatment plant and solids processing facilities with an average daily hydraulic capacity of 545 ML.

The operating costs of the collection[1,2] and treatment[2] of the RMOC wastewater has been reduced from a high in 1994 of $22,140,000 to a 1997 year end forecast of $10,750,000. This huge cost reduction has been realized from both operations and maintenance (O&M) optimizations and from changing management practices.

With privatization of publicly provided services having a high profile in the nineties, the RMOC staff responsible for wastewater collection and treatment quickly became aware of the need to change past business practices to ensure the operating expense budgets were developed and managed in a competitive manner. Adopting a "bottom line" approach to business decisions became a priority to the way services were delivered to the taxpayers of the RMOC.

The RMOC began to study those O&M requirements that consumed major expense dollars to find alternative methods to optimize O&M costs. The major issues reviewed were:

Contracted services, what could be done by RMOC staff?

Salaries and benefits, what is the right complement of staff?

Chemicals and utilities, what opportunities exist from process change or automation?

Property taxes, do they inflate or cloud the expense budget picture?

Accounting practices, are they consistent with typical budgets of the private sector?

In 1992 the operational needs of the wastewater treatment plant were met by RMOC staff operating and maintaining the wetside of the plant. A private contractor took the responsibility for the O&M requirements of the solids processing side of the plant. Initially, this combination worked very well from a process performance perspective but in a short time the RMOC became aware of the economies of integrating the plant operation under a single operator. The RMOC terminated the private operator contract in 1995 and took over the responsibility of the O&M requirements for the entire plant. This resulted in an operating cost benefit of $3,000,000 per year.

Organizational changes that reduced the supervisor/manager to worker ratio and cross certification of O&M staff have resulted in a smaller but effective staff complement.

Almost all trades personnel were certified as collection or treatment operators. There are no "pure' operators as such on staff now. Right sizing the O&M staff complement has resulted in staffing reduction to 76 persons from 117 in 1994. This resulted in approximately $2,471,000 in salaries and benefits. In addition to the 117 RMOC staff in 1994, there were 22 private sector staff operating the solids processing facilities.

Budgeting practices moved closer to a zero base budget development strategy. No longer are large sums of money allocated to miscellaneous repairs and maintenance cost centers only to have the unspent portions charged against the expense budget and diverted to a reserve fund. Major repairs and equipment overhauls are budgeted for in a capital budget rather than the operating expense budget. This capital budget allocation does not lower the costs to the RMOC to complete the work but is more consistent with the practices of the private sector and allows for easier comparison of costs with those in privatization proposals. Just as capital costs were removed from the RMOC operating budgets, property taxes were set outside of the operating expense budget of the wastewater treatment plant. If a private operator were to take on O&M responsibilities most common agreements find the facility owners absorbing the costs of property taxes as well as upgrades and major overhauls as capital expenditures.

Continual detailed stewardship of operating costs relative to process performance (i.e. $ per tonne of solids removed from site, kilowatt hours of power purchased per M^3 of plant influent, kilograms of polymer per tonne of solids in dewatering feeds) focused the O&M staff on areas for optimization opportunities. The following are some of the opportunities that resulted in cost optimizations.

- Develop a long term biosolids utilization strategy and competitively tender beneficial use programs to lower operating costs and reuse beneficial by-products. Cost reduction of $1,300,000 per year.
- Competitively tender and conduct plant scale tests on the dewatering polymer to find the best product. Cost reduction of $110,000 per year.
- Reduce potable water consumption with seal water optimization studies, make instrumentation changes to reduce cooling water flow rates and substitute potable water with effluent water for cooling requirements. Cost reduction $160,000 per year.
- Switching from ferric to ferrous chloride for phosphorus removal resulted in lower unit costs and process control resulted in a reduction of chemical consumption. Cost $150,000 per year.
- Electrical cost savings by using polymer to enhance waste activated sludge thickening during the winter. Minor net savings in electrical and maintenance costs. Cost reduction of $10,000/year.
- Electrical/ thermal cogeneration fuelled by anaerobic digestion off gases

commissioned in late 1997. Forecast net savings are $550,000 per year.

- Removing grants in lieu of taxes from operating expense budget produced a budget reduction of $1,600,000 per year.
- Zero base budgeting and allocation of capital fund reduced operating expenses by $110,000 per year.
- Improved polymer application through the use of high mixing energy technology resulted in a savings of approximately $50,000 per year.
- Elimination of the contribution to the sewer maintenance reserve fund reduced the operating budget by $500,000 per year.

Note 1: O&M of the collection system is for the main truck sewers and pumping stations only. The local collection facilities are operated and maintained by local municipalities.

Note 2: Buildings and grounds maintenance costs are not included. These costs are managed by a centralized property management group external to wastewater collection and treatment.

9.1.4 *Regional Municipality of Durham, Water Supply System*

The Regional Municipality of Durham operates 14 water systems. The three largest are interconnected and controlled through a central computer system. The total water supply capacity from these three plants equals 281,820 M^3/d. The three plants are known as the Oshawa/Whitby/Ajax Water Supply System.

At the present time, water from either the Oshawa WSP or the Whitby WSP can be interchanged. Water from Oshawa or Whitby can be pumped into the Ajax system but can not be pumped in the return direction.

The power costs to operate the Oshawa/Whitby/Ajax Water Supply System represents 46% of the annual budget. Staff have developed ways of conserving energy by scheduling certain operations to off peak hours and since each of the water supply plants is supplied hydro power through different PUC's, the rate structures facilitate power savings by shifting water pumping from Oshawa to Whitby and vise versa.

As can be seen in the table below, Oshawa's Hydro rates are both cheaper and more expensive than Whitby's, depending on the time of day or week. Therefore, the strategy is to reduce flows at the Oshawa Water Plant to a minimum constant level during "On Peak" hours and produce the rest of the required water at the Whitby Water Supply Plant. Then, when Oshawa is on "Off Peak" rates, Oshawa is operated at as high a flow rate as possible and Whitby is kept at a low flow rate.

PUC Hydro Rates

Whitby Hydro Rates $0.057/KWH

Oshawa Hydro Rates	(Winter)[1]	(Summer)[2]
[3]Off Peak	$0.0342/KWH	$0.0235/KWH
[4]On Peak	$0.0866/KWH	$0.071/KWH

[1]October to March inclusive

[2]May to September inclusive

[3]Monday to Friday 11:00 PM to 7:00 AM
Friday 11:00 PM to 7:00 AM Monday

[4]Monday to Friday 7:00 AM to 11:00 PM

A further advantage of shifting the pumping between the two plants is in the area of Peak Demand Charges. At Oshawa, the Peak Demand is only assessed during "On Peak" hours. By following the above schedule at all times, we obtained a much Lower Peak Demand charge. Whitby's Peak Demand charges are somewhat higher as result of this strategy but not to the point of negating the savings made at Oshawa.

As a result of the schedule, we have transferred approximately 144,000 KWh of power from Oshawa to Whitby each month for a saving of $3,974.40 during the hours of 7:00 AM to 11:00 PM Monday to Friday. On the weekends, approximately 32,000 KWh are transferred from Whitby to Oshawa for savings of $729.60 each month. The total savings is approximately **$4,700.00 per month**.

Through experimentation, it is apparent that we can reduce our Peak Demand at the Oshawa WSP through the months of October to May, to less than **0.9 Megawatts**. The typical Peak Demand before this program was **1.6 Megawatts**. Whitby's Peak Demand has increased but the net result has been a savings of approximately **$3,800.00**.

The total savings in power through this program equals **$8,500.00 per month** during the period of October till end of March. During the months of April, May and September the savings would be smaller because of the lower Peak Demand and Consumption rates in Oshawa. The estimated savings for Demand and Consumption are **$1,500.00** and **$2,800.00** respectively; for a total of **$4,300.00 per month**.

During the summer months, the lack of treatment capacity makes it difficult to maintain adequate water levels in the system reservoirs, and therefore shifting of water pumping must wait until lower water demands occur. The estimated total annual energy savings is approximately $64,000.

Other Success Stories from Canadian and Foreign Sources

A number of success stories have been documented from Canadian and foreign sources for the reader's reference. The number of Canadian cases presented is limited. Although many facilities have implemented resource savings, most plants have not monitored and documented before and after resource uses nor have they published results. In these descriptions, payback periods are also presented where available.

9.2.1 Woodstock WPCP, City of Woodstock, Ontario, [11] – 36 ML/d

The facility retrofitted the existing positive displacement blowers and multi-stage compressors with single-stage, dual-vane, high efficiency compressors at a cost of $194,225.

At an estimated annual electrical savings equivalent to $77,246, a payback period of 2.5 years was expected. The inclusion of an Ontario Hydro incentive resulted in an actual savings of $87,677 in the first year of operation (1993), reducing the payback period to 1.4 years.

9.2.2 Tillsonburg STP, Ontario [12] & [13] – 8.2 ML/d

An on/off aeration demonstration was undertaken at the Tillsonburg STP. By simple operational changes and minor low-cost retrofits in the operation of the nitrifying activated sludge wastewater treatment plant, a savings in oxygen requirements due to denitrification and an increase in the oxygen transfer efficiency was achieved.

A 16% energy saving was achieved from cycling one tank only and 26% savings was realized when two tanks were cycled.

The plant also implemented an optimization and automation program for the oxygen transfer equipment. An approximate energy savings of 15 percent was achieved.

9.2.3 Preston WWTP, Regional Municipality of Waterloo, Ontario [10] – 28 ML/d

Model simulation indicated that DO control could result in an annual 30 % energy use savings of $30,000, compared to the case without DO control.

9.2.4 Burlington Skyway WPCP, Ontario [13] – 93 ML/d

The plant implemented improvements to the chemical feed system for phosphorus removal. This resulted in a 30 percent reduction in chemical use with an annual savings of $30,000.

9.2.5 Pottersburg PCP , London, Ontario [7] – 28.2 ML/d

The project upgraded two sections of the plant consisting of a biological nutrient removal system without tank addition. A 6% reduction in power and a 70 % reduction in chemical use were realized.

9.2.6 Glastonbury WWTP, Connecticut [3] – 3.6 MGD

The plant retrofitted original coarse-bubble diffusers with 320 rigid porous plastic diffuser tubes and an air blower at a cost of $28,000 US. Oxygen transfer efficiencies improved from approximately 4-4.5% to 6.5-7%.

Blower energy reduction resulted in annual electrical savings of up to $18,000 US, yielding a payback period of approximately 2 years not including cleaning costs.

9.2.7 Hartford WWTP, Connecticut [3] – 60.0 MGD

The plant retrofitted original coarse-bubble spiral roll aeration system with a fine-pore dome diffuser system at a cost of less than $600,000 US. Oxygen transfer efficiencies improved from approximately 4.4% to 10%. Hosing (with a cleaner that contains 22% hydrochloric acid), brushing and rehosing was performed to clean diffusers, which reduced the pressure drop through the diffusers and resulted in reduced energy use.

Annual operating savings exceeded $200,000 US for the first year and the corresponding payback period is less than 3 years.

9.2.8 Cleveland WWTP, Wisconsin [3] – 0.2 MGD

This package plant retrofitted original coarse-bubble diffusers with porous plastic plate fine-pore diffusers and new blowers at a cost of $11,500 US.

Blower energy reduction resulted in annual electrical savings of $2,400 US, yielding a payback period of approximately 5 years.

9.2.9 Plymouth WWTP, Wisconsin [3] – 1.65 MGD

The plant retrofitted original surface aerators with ceramic disk diffusers and an air blower and blower building at a cost of $220,000 US.

Blower energy reduction resulted in annual electrical savings of $20,000 US, yielding a payback period of approximately 11 years.

9.2.10 Renton WWTP, Washington [3] - 72 MGD

The plant retrofitted original coarse-bubble diffusers with perforated flexible membrane tube diffusers at a cost of $380,000 US. In-situ hydrogen chloride gas installed to keep the membrane diffusers from blocking. Improves field oxygen transfer efficiencies were estimated to average 7.2%.

Blower energy reduction resulted in annual electrical savings of $92,500 US, yielding a payback period of approximately 4 years.

9.2.11 Ripon WWTP, Wisconsin [3] – 2.0 MGD

The plant retrofitted original coarse-bubble diffusers with ceramic disk diffusers. In situ hydrogen chloride gas cleaning was provided for preventative use, cleaning is expected to be once per year or less

Blower energy reduction resulted in annual electrical savings of $29,300 US.

9.2.12 Saukville WWTP, Wisconsin [3] - 0.5 MGD

The plant retrofitted original coarse-bubble diffusers with ceramic disk diffusers at a cost of \$44,000 US. In situ hydrogen chloride gas cleaning was provided for preventative use, expected to be used 3-4 times a year. However, monitoring revealed rapid and heavy fouling of diffusers and it was required 4 times in first 7 months of operation.

Blower energy reduction resulted in annual electrical savings of \$7,300 US, yielding a payback period of approximately 6 years.

9.2.13 City of Fairfield, Ohio

The City combined their purchasing of chemicals with six other cities to reduce costs by purchasing chemicals in bulk. The seven cities combined their water treatment chemical needs and bid out the supply of chemicals to dealers in order to determine the most economical bid.

This program has been in effect for the last seven In situ hydrogen chloride gas cleaning was en years and cost savings of up to 30% have been achieved. There were no reductions in chemical use with this approach.

9.2.14 Columbia WWTP, Columbia, Tennessee [4] – 7.0 MGD

The plant installed dissolved oxygen monitors in aeration tanks and adjustable speed drives on aeration blowers. Reduction in blower energy requirements resulted in 24% annual savings in electricity costs.

9.2.15 Willits WWTP, Willits, California [4] – 0.7 MGD

The plant installed variable speed drives on raw wastewater pumps. The result was a 39% reduction in electricity use compared to the previous two-speed operation.

9.2.16 Washington WWTP, Piscataway, Maryland [4] – 30 MGD

The plant installed computer controls for the operation of nitrification blowers. New instrumentation also included control valves and dissolved oxygen analyzers. Electricity use was reduced by 34% compared to manual control

9.2.17 Pacifica WWTP, Pacifica, California [4]

The plant installed adjustable frequency drives on aeration blowers and raw wastewater pumps. Improvements to instrumentation and controls also included dissolved oxygen monitors and PLC's. Power savings of over \$20,000 per year were realized. Power factor increased from 65-70% to 95%.

9.2.18 Durham WWTP, Durham, Oregon [4] – 20 MGD

Installation of fine bubble diffusers and dissolved oxygen control system resulted in a reduction in electricity use of 21%, or 12,000 kWh/day.

9.2.19 *Dallas Central Regional WWTP, Dallas, Texas [4] - 90 MGD*

The plant retrofitted original coarse-bubble diffusers with fine pore diffusers. Horsepower requirements were reduced by 25%.

9.2.20 *Flint WWTP, Flint Michigan [4] -50 MGD*

The plant installed fine pore diffusers, resulting in annual energy savings estimated at $450,000 to $575,000 US per year.

9.2.21 *Greater Lawrence Sanitary District WWTP, N. Andover, MA [4]*

The plant installed variable speed drives on mechanical aerators and installed a dissolved oxygen control system. A 25% reduction in energy yielded a payback period of approximately 3.3 years. The local PUC also provided a rebate.

9.2.22 *Taylorville Sanitary District WWTP, Taylorville, Illinois [4] - 3 MGD*

The plant decreased use of tertiary lagoons; increased frequency of blower filter cleaning; reduced clarifier operation; and installed fine bubble diffusers. A 13% reduction in power use was recorded in the first six months of operation.

9.2.23 *New Jersey American Water Company Water Systems [4]*

The New Jersey American Water Company has retrofitted various facilities throughout the state as follows:

(a) Installation of variable frequency drives (VFD) to control one of four 112 kW reservoir intake pumps.

The result was increased operation of pumps on the generator, thereby increasing curtailable service (CURX) by 112 kW, resulting in savings of $51,000 US.

(b) Installation of VFD on one 75 kW booster station pump.

The result was increased control of pressures and flows, daily tank storage life increased from 4 to 12 hours, and annual savings of $13,900 US.

(c) Installation of VFD on a 187 kW vertical turbine high service pump.

The result was the matching of supply to system pressure requirements by eliminating pump throttling and/or pump starting and stopping, which yielded an annual saving of $85,600 US.

(d) Installation of VFD on one of three 112 kW booster station pumps.

The result was the matching of supply to system pressure requirements by eliminating pump throttling and/or pump starting and stopping, which yielded an annual saving of $85,600 US.

(e) Installed on VFD on one of three 112 kW booster station pumps.

This system replaces throttling valves, resulting in annual savings of $33,700 US.

9.2.24 City of Vernon, British Columbia

A water conservation program was initiated consisting of metering water consumption, modifying water and sewer rate charges and installing home water conservation packages in approximately 4600 homes. The home package consisted of pop flusher toilets throughout the home, low flow shower heads (90 L/M), swivel aerators for kitchens and aerators for all bathroom faucets.

The capital cost for this program was $1.2 Million and the expected savings are between $30,000 to $40,000 on the wastewater side alone. Although the annual water treatment and distribution savings have not been assessed, an estimated $2.0 Million will be saved in scheduled plant upgrades over the next 20 years.

9.2.25 Town of Winkler, Manitoba

A water conservation program was initiated consisting of a lawn watering restriction to odd/even days for odd/even numbered homes for 2000 homes. This measure reduced peak water use and people were also encouraged to use less water through a general awareness program.

The annual cost of running this program is $1,000 per year and the expected savings for water and wastewater treatment and deferring of treatment expansions is $2.0 Million over the next 6 years.

9.2.26 City of Aurora, Colorado [8]

To reduce water system demand, the City of Aurora Department of Utilities distributed 13,000 residential retrofit kits to about 35% of the utility's services. The kits included a toilet tank dam, two showerhead restructures, and two toilet tank leak detection tablets.

The program cost was $16,000 US and resulted in a 6% reduction in indoor water usage.

9.2.27 City of Leavenworth, Washington [8]

The City began installing individual water meters in 1988, which immediately reduced summer usage by 18%. In 1990, the water rate structure was changed to allow seasonal adjustments in water rates, with charges based on consumption. Consumption during the peak summer months dropped by 43% compared to the previous year.

9.2.28 City of LaVerne, California [8]

The City achieved a 20% reduction in water use through a water conservation program implemented in 1991. The program involved restricting wasteful practices, implementing a drought surcharge on the water bill, and developing public awareness with education programs.

9.2.29 Harris County, Texas [8]

To alleviate over pumping of aquifers in the area, Harris County Municipal Utility District conducted a retrofit project, wherein residents were offered a free retrofit kit containing a low-flow showerhead, bathroom faucet aerator, sink aerator, and conservation literature. The homes that installed the kits reduced water use by 18%. Also, new state legislation requires ultra low-flush toilets for all new construction.

9.2.30 North Marin County Water District, California [8]

The North Marin County Water District offers cash credits to customers, based on district guidelines for outdoor landscaping. The guidelines are the outcome of research that showed that planned unit developments with efficient landscaping (i.e. reduction in turf area compared to traditional landscapes, use of water-conserving shrubs, etc.) resulted in 54% water savings.

9.2.31 Metro Toronto, Ontario

Approximately $300,000 annual hydro savings have been achieved through management of monthly peaks and off-peak pumping during the past two years. Metro is also investigating the potential for more significant savings in the future through distribution system operational optimization

9.2.32 Region of Durham, Ontario

Significant savings were recently achieved at the raw sewage lift station. Three 450 hp screw pumps lift sewage so it can flow through the plant by gravity. In the event of a power failure, the incoming sewage line can be surcharged to a level where sewage is high enough to enter the discharge channel of the lift screws and flow downstream for treatment. When this happens, the velocity through the 3000 mm pipe is reduced causing some heavier solids to settle in the pipe.

To reduce power usage at the plant, they made a conservative estimate of how long we could shut these pumps without building significant solids in the pipe and overloading the grit separation system when the pumps are turned back on. They found that the ultimate shutdown period was Monday to Friday or four full days. They have been operating this way for the last six months. Their 1996 power bill was $1,973,000 and the anticipated savings for 1997 are $195,000.

9.2.33 City of Barrie, Ontario

The implementation of a Residential Wastewater Conservation Program throughout 1995-1998 in which 14,000 ultra low-flush toilets replaced existing fixtures as well as the distribution of low-flow showerhead and faucet aerator has led to a reduction of 63 liter per day per capita. This may allow the PUC to postpone capital expenditure on the building of the new lake water treatment plant. In addition, the estimated 1,700 M^3 per day reduction in wastewater flow to the municipal's treatment facilities has deferred expansion by five years at savings of $2.0 million.

Initiatives to optimize the unit processes within the treatment facilities including Dual Digestion, Co-generation and UV Disinfection are currently under construction. The results of these initiatives will be available in early 1999. Future initiatives under consideration include Waste Activated Sludge Thickening and Filtration and Biosolids Storage Facilities.

In Dual Digestion, raw sludge and scum from primary settling tanks is pumped to Aerobic digestion. Industrial grade oxygen injected into this sludge promotes microbial activity and auto-thermal reactions raise the temperature to 55-60 degrees C. The hot sludge is then pumped to primary Anaerobic digestion where the sludge is gas mixed, digestion takes place at 35 to 40 degrees C and the breakdown of organic material occurs. All the heat required for the Anaerobic digestion is imparted to the sludge by the preceding oxygen-aided exothermic reaction in the digester. This makes all recovered digester gas available for other energy recovery applications. Also, compared to conventional anaerobic digestion, Dual digestion kills more pathogens allowing more choices for off-site utilization of cleaner biosolids and for reducing the hydraulic retention time for sludge stabilization. Alternatively, there is a potential for increased capacity for sludge digestion.

In the final step in Dual Digestion, two unheated secondary digesters receive material from primary Anaerobic digesters and complete the process in a quiescent state thus permitting sludge settlement and formation of a thinner layer of supernatant on top. Supernatant is to the treatment process. The final biosolids product is a black, relatively odorless slurry which is used as a fertilizer and soil conditioner on agricultural land.

T he UV disinfection system will result in environmental benefits by eliminating the release of chlorine by-products into the aquatic ecosystem while providing a better bacteriological treatment of the wastewater effluent.

10. Other Useful Information

Additional information relevant to the water and wastewater industry is summarized here.

10.1 Associations and Agencies and Their Websites

There are a number of associations and agencies that are involved in the water and wastewater industry. These groups provide access to literature containing a wealth of knowledge and information and further contacts in their respective fields. This includes reports, studies, journals, seminars, conferences, training and other very useful documentation and support and information services regarding specific conservation measures. An Internet document search on the association's web site or a telephone call to the association will assist in the search for information.

Some of the relevant associations and agencies for the water and wastewater industry in Ontario and nationally in Canada are identified below with Internet locations where applicable:

Ontario

- Ministry of Environment, MOE, *www.ene.gov.on.ca*
- Ontario Water Works Association, OWWA, a Section of the American Water Works Association, *www.oww.org/owwa.html. This is a joint website* called the Ontario Water and Wastewater Website.
- Water Environment Association of Ontario, WEAO, *www.oww.org/weao.html*
- Ontario Municipal Water Association, OMWA
- Association of Municipalities of Ontario, AMO
- Conservation Ontario
- Ontario GroundWater Association, OGWA
- Ontario Clean Water Agency, OCWA
- Ontario Sewer and Watermain Construction Association, OSWCA, *www.oswca.org*

Canada

- Canadian Water Resources Association, CWRA, *www.cwra.org*
- Canadian Water and Wastewater Association, CWWA
- Environment Canada, *www.doe.ca*
- Health Canada

- Fire Underwriters Survey

International (mainly U.S.A. based)

- Water Environment Federation, WEF, *www.wef.org*
- Water Environment Research Foundation, WERF, *www.werf.org*
- American Water Works Association, AWWA, *www.awwa.org*
- American Water Works Association Research Foundation, AWWARF, *www.awwarf.com*
- Air and Waste Management Association, AWMA, *www.awma.org*
- U.S. Environmental Protection Agency, EPA, *www.epa.gov*
- Electric Power Research Institute, EPRI, *www.epri.com*
- Association of Energy Engineers

10.2 Pollution Prevention and Resource Conservation Guidance Documents, Manuals and Directories

There are a number of documents available that will provide more detailed information on specific conservation measures. Documents include reports, studies, technical memoranda and conference proceedings.

10.2.1. Guidance Documents and Manuals

Reference documents identified in Section 11 should provide additional information on this report. Other types of documents that periodically contain information on the issues covered in this report and will assist the reader include:

- AWWA and WEF conference proceedings and abstracts
- Water Quality and Treatment, A Handbook of Community Water Supplies (Fourth Edition) – AWWA.
- Natural Resources Canada. A Manager's Guide to Creating Awareness of Energy Efficiency. Efficiency and Alternative Energy Program.
- Natural Resources Canada. 1994. Technical Information. Efficiency and Alternative Energy Program.
- Canadian Industry Program for Energy Conservation. CIPEC Energy Efficiency Planning and Management Guide.
- Ontario Ministry of Environment and Energy. 1993. Pollution Prevention Planning: Guidance Document and Workbook. PIBS 2586E. ISBN 0-7778-1441-2.

- Canadian Standards Associations. 1994. Guideline for Pollution Prevention. Z754-94.
- Canadian Standards Associations. 1994. Environmentally Responsible Procurement. Z766-94.
- Ontario Waste Management Corporation (OMWC). 1993. Industrial Waste Audit and Reduction Manual. 3rd ed.
- Environmental Approvals Guidance Documents
  - Ontario Ministry of Environment and Energy, Approval's Branch. Guide for Applying for Approval of Industrial Sewage Works. November, 1994.
  - Ontario Ministry of Environment and Energy, Approval's Branch. Guide for Applying for Approval (Air). November, 1994.
- **The MOE Industry Conservation Branch has prepared a number of guides covering industries that contribute to the input loadings to municipal wastewatetreatment facilities. "Guides to Resource Conservation and Cost Savings Opportunities" have been prepared for the following sectors:**
  - **Meat & Poultry Processing**
  - **Dairy Processing**
  - **Adhesives, Paints and Coatings**
  - **Soap, Detergents and Related Products Sector**
  - **Plastics Reprocessing**
  - **Automotive Parts Manufacturing**
  - **Plastics Reprocessing**
  - **Food Services**
  - **Office Buildings**
- California Department of Health Services and U.S. EPA – Operator Training Manuals for:
  - Water Treatment Plant Operation
  - Small Water System Operation and Maintenance
  - Water Distribution System Operation and Maintenance
  - Operation of Wastewater Treatment Plants
  - Operation and Maintenance of Wastewater Collection Systems

10.2.2 Directories

- Ontario Environment Business Directory, 1998 Edition

  This directory provides contact information and description of products, technologies and services offered by 500 environmental businesses in Ontario. The directory is indexed by the following market segments:

  -air pollution prevention and control

  -energy efficiency / renewables

  -environmental contracting and engineering

  -environmental monitoring, analysis and assessment

  -noise/vibration abatement

  -site remediation

  -solid and hazardous waste management

  -water and wastewater treatment/water conservation

  For copies of the Ontario Environment Business Directory contact the Green Industry Office, MOE, at (416) 323-4597, fax (416) 323-4436 or email defoebr@ene.gov.on.ca

- Natural Resources Canada. 1994. CEMET Resource Catalogue: List and Description of Available Energy Efficiency Products and Services.

10.3. Environment Management Systems and ISO 14000

One final area that warrants consideration is the introduction of Environmental Management Systems (EMS) in the water and wastewater industry. An EMS constitutes an organization's approach and procedures for considering environmental effects and impacts of its operations, decisions and policies. By extension, EMS involve the internal organizational structures and procedures by which a business takes environmental implications into account.

There are a number of methodologies that can be used, including the use of the ISO 14000 standards. In the public sector, the Regional Municipality of Waterloo Waste Management and Landfill Department is working towards an ISO 14000 designation. The water and wastewater sector may benefit from a similar approach. The ICB of the MOE is preparing ISO 14000 guides in a number of industry sectors. For further information, please contact the ICB.

11. REFERENCES

Information referenced in this study is identified throughout the report with the identification number, [#], corresponding to the list below.

[1] Performance Benchmarking for Water Utilities, AWWA Research Foundation (1996)

[2] Benchmarking Wastewater Treatment Plant Operations, Water Environment Research Foundation (1996)

[3] Energy Conservation in Wastewater Treatment Facilities, WEF (1997)

[4] Water and Wastewater Industries: Characteristics and Energy Management Opportunities, EPRI's Community Environmental Center (1996)

[5] State of the Debate on the Environment and the Economy: Water and Wastewater Services in Canada, National Round Table on the Environment and the Economy (1996)

[6] Municipal Water and Wastewater Treatment Facilities in Ontario: An Assessment of Electricity Use and the Impact of Environmental Regulation, Ontario Hydro (August 1993)

[7] Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector, MOE (September 1995)

[8] Water Conservation Guidebook For Small and Medium Sized Utilities, AWWA (August 1993)

[9] Tasfi, L, et al, "Improving WPCP Performance and Increasing Capacity without Major Capital Investment – City of London Case Study," presented at the 26th Annual WEAO Technical Symposium, London, Ontario, April 13-15, 1997.

[10] Briggs, T, D. Ross, M. Hribljan, and K. Cober, "Use of Dynamic Biological Simulation Model to Optimize Secondary Treatment Process Sizing at the Preston WWTP," presented at the 26th Annual WEAO Technical Symposium, London, Ontario, April 13-15, 1997.

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[11] Mace, G., and G.R. Slater, "Case History - Retrofitting of Existing Blowers at the Woodstock, Ontario WPCP Saves Dollars," presented at the 26th Annual WEAO Technical Symposium, London, Ontario, April 13-15, 1997.

[12] Phagoo, D, R, M, Jones, A. Ho, "Demonstration of On/Off Aeration at a Municipal STP in Ontario for Denitrification and Energy Savings: Status Report," presented at the 25th Annual WEAO Technical Symposium, Toronto, Ontario, March 24-26, 1996.

[13] Nutt, S, and D. Ross, "What is Optimization and Why Optimize?," presented at the 24th Annual WEAO Technical Symposium, Toronto, Ontario, April 2-4, 1995.

[14] Water Quality and Treatment, 4th Edition, AWWA.

[15] Water Resources Branch, MOE, "Report on the 1991 Discharges from Municipal STPs in Ontario", June 1993.

[16] Eyre, T., Chair, OWWA, Personal Communication, November 1996.

[17] Barnhart, E.L., "An Overview of Oxygen Transfer Systems", Proceedings: Seminar. Workshop on Aeration Systems: Design, Testing, Operating and Control, EPA-600/9-85-005, January 1985.

[18] Demonstration of On/Off Aeration At A Municipal Sewage Treatment Plant In Ontario For Denitrification And Energy Savings, March 1996, MOE

12. GLOSSARY OF ACRONYMS

ATAD	Autothermal Thermophilic Aerobic Digestion
AWWA	American Water Works Association
B.C.	British Columbia
BOD	Biochemical Oxygen Demand
C of A	Certificate of Approval
CT	Concentration Time
DO	Dissolved Oxygen
EPRI	Electric Power Research Institute
GAC	Granular Activated Carbon
HVAC	Heating, Ventilation and Air Conditioning
HVMS	High Velocity Mixing Systems
ICB	Industry Conservation Branch
kW	Kilowatt
kWh	Kilowatt Hours
ML/d	Million Liters per Day
MOE	Ministry of Environment
O&M	Operation and Maintenance
OCWA	Ontario Clean Water Agency
OWWA	Ontario Water Works Association, a Section of the AWWA
PAC	Powder Activated Carbon
PCP	Pollution Control Plant
PLC	Programmable Logic Computer
PRV	Pressure Reducing Valve
RAS	Return Activated Sludge
SCM	Streaming Current Monitor
STP	Sewage Treatment Plant
US EPA	United States Environmental Protection Agency
VFD	Variable Frequency Drive
VOC	Volatile Organic Compound
WAS	Waste Activated Sludge
WEAO	Water Environment Association of Ontario
WEF	Water Environment Federation
WTP	Water Treatment Plant
WPCP	Water Pollution Control Plant
WWTP	Wastewater Treatment Plant
[#]	Reference Numbers in Square Brackets from Section 11

APPENDIX A
LEGISLATION, REGULATIONS AND STANDARDS

WATER RESOURCES

Ontario Fisheries Act – Administered by the Ontario Ministry of Natural Resources

This legislation can impact water and wastewater facility construction and operation and prohibits 'any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat'. This Act does not usually have significant impacts on the operation of water and wastewater facilities.

Ontario Water Resources Act – Administered by the MOE

This legislation governs the design and operation of municipal water and wastewater facilities in Ontario. A Certificate of Approval © of A) must be obtained from the MOE prior to constructing, expanding or operating a treatment facility. Typically the Certificates of Approval specify the treatment process and flow rates; effluent quality requirements for wastewater facilities; and, drinking water quality monitoring.

Model Sewer Use By-Law

This by-law establishes maximum limits of discharges of contaminants to sewers and is being used by many municipalities as a guidance document to establish their own Municipal Sewer Use By-Laws.

Municipal Sewer Use By-Laws

These statutes govern the quantity and quality of industrial wastewater discharges to municipal sewers. Many of these by-laws are adapted by municipalities from the MOE's Model Sewer Use By-Law.

Ontario Environmental Assessment Act

This legislation requires that an environmental assessment process be carried out for any project with environmental impact, such as treatment plant expansions and new facilities.

Ontario Public Lands Act – Administered by the Ministry of Natural Resources

This legislation requires issuance of a Work Permit prior to undertaking work on public lands. Its main impact is on intake and outfall structures through specific restrictions on construction that affects shorelines. This legislation tends to have a physical impact on design, (i.e., location) and not a treatment process impact.

Ontario's Provincial Water Quality Objectives

The 1994 publication gives direction on how to manage the quality and quantity of both surface and ground waters. Ontario Drinking Water Quality Objectives provide the basis for treated water quality. Ontario Surface Water Quality Objectives are used, as the basis for determining the level of wastewater treatment required to protect surface waters.

Water Management: Goals, Policies, Objectives and Implementation Procedures of the Ministry of Environment

This policy sets out the MOE's overall water management program to maintain surface water and groundwater quality and quantity.

Ontario's Policy on Pollution Prevention

This recently developed policy stresses pollution prevention rather than control and its long-term impacts are expected to improve raw wastewater quality requiring treatment at municipal wastewater treatment plants.

Ontario Policy on Water Efficiency

This policy was developed to change water usage practices. The long-term goal is to delay the need for an expansion municipal water and wastewater facilities.

Ministry of the Environment Policy on Secondary Treatment

This policy specifies that secondary or equivalent treatment is the minimum level of treatment for effluent prior to discharge to surface waters in Ontario. This policy is not retroactive and therefore does not affect existing plants. Recent changes to the policy include the use of equivalent standards that allow for a blend of chemically assisted primary and secondary treatment as long as the goals and objectives of secondary treatment are met.

MOE Design Guidelines

This document provides guidelines for the design of water and wastewater treatment facilities and water distribution and wastewater collection systems. These documents are used to define the minimum design requirements for approval from the MOE (when no other information is available) and include design parameters and normal to maximum levels of operation.

Ministry of the Environment Policy on Treatment Requirements for Municipal Water Treatment Using Surface Water Sources

This policy stipulates that water treatment facilities that use surface water should incorporate coagulation, flocculation, filtration and disinfection as a minimum level of treatment. This policy is not retroactive and will only affect existing facilities when they are expanded.

AIR RESOURCES

Ontario Environmental Protection Act

This legislation addresses the discharge of pollutants into the natural environment and prohibits the discharge of deleterious substances into the atmosphere.

Ontario Regulation 346

This legislation provides the primary control of discharges into the atmosphere and establishes maximum limits for contaminant discharges. These requirements impact on the design and operation of sludge incineration systems in particular.

Solid Wastes

Ontario Environmental Protection Act

This legislation addresses the disposal of solid wastes but does not directly impact the technologies used in this industry that are approved by the Ontario Water Resources Act. This legislation does, however, directly impose specific requirements on waste disposal sites such as landfills and land application sites.

Ontario Regulation 347

The regulation addresses ash quality requirements generated by incineration of wastewater treatment biosolids, which are disposed in landfills. The ash by-products are subjected to leaching tests to define a classification that impacts on the disposal requirements.

Ontario's Policy on Pollution Prevention

The prime impact of this policy will be on industrial pretreatment and its impacts on wastewater treatment will be over the long-term. Reducing or eliminating the creation of contaminants at the source should improve the quality of the wastewater entering treatment plants which in-turn will improve the quality of biosolids.

Ministry of Environment Policy on Filter Backwash Solids

This policy will likely change the current practices for disposing of filter backwash solids from municipal water treatment facilities and in the long-term will impact facilities using surface water supply.

APPENDIX B
SURVEY DATA

(PAGES 93- 107)

Figure 5.1.1 - Annual Energy Usage in Water Plants (All Plants)

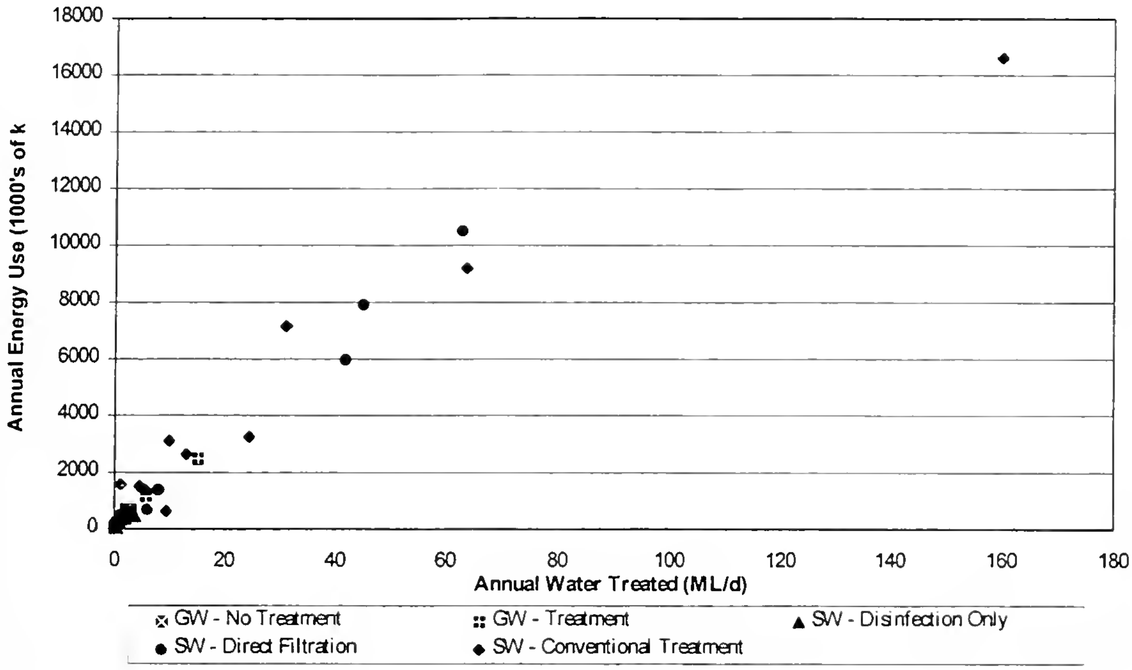
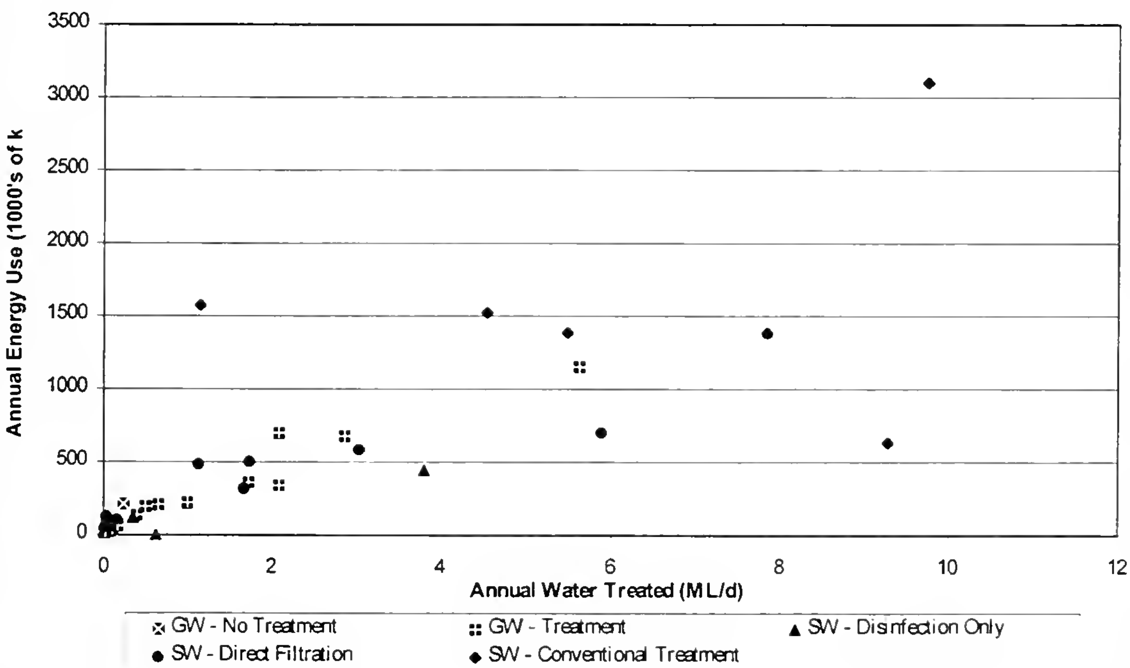


Figure 5.1.2 - Annual Energy Usage in Water Plants (Treated Water <10 ML/d)



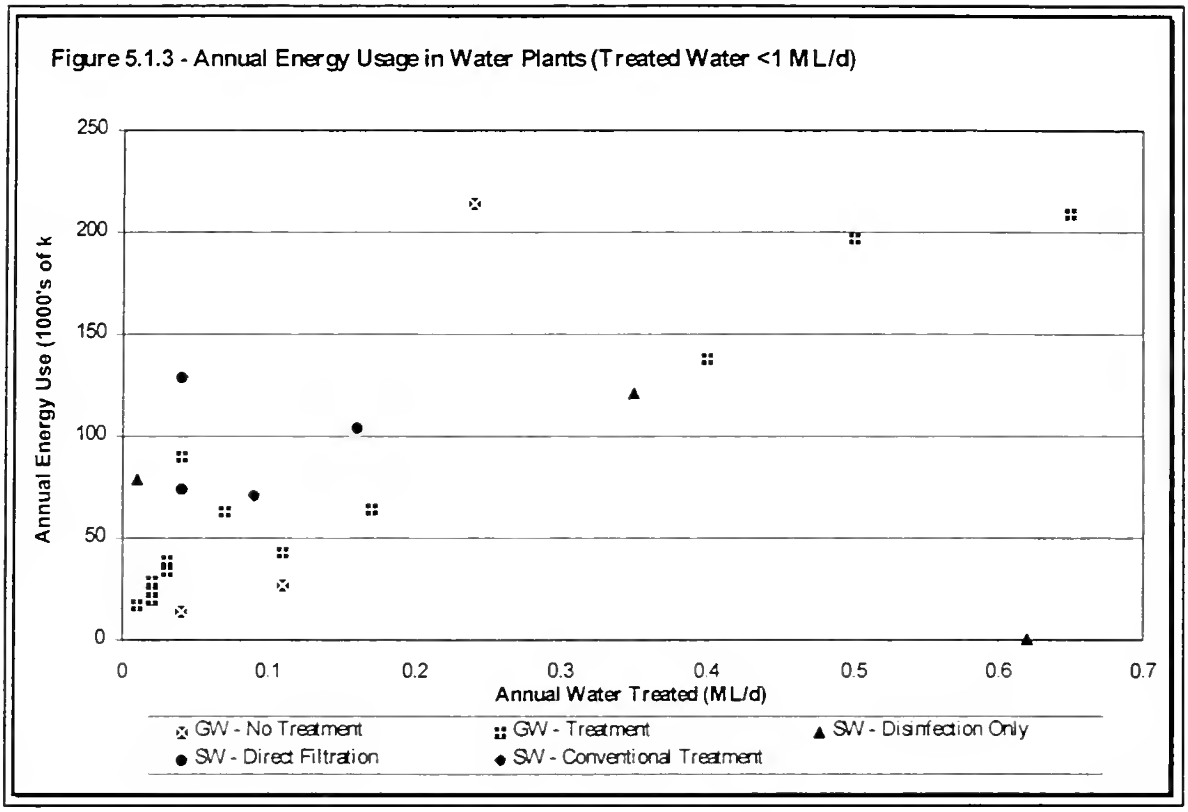


Figure 5.1.3 - Annual Energy Usage in Water Plants (Treated Water <1 ML/d)
Annual Energy Use (1000's of k
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

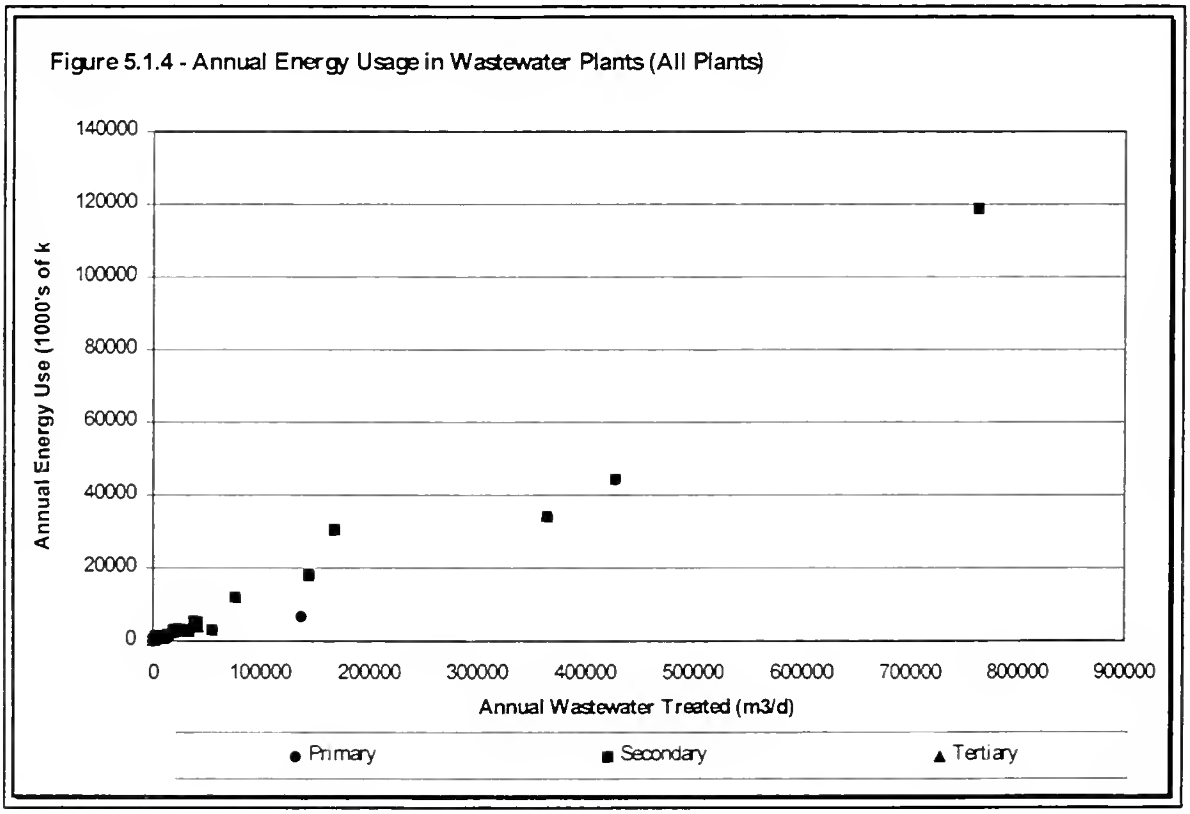


Figure 5.1.4 - Annual Energy Usage in Wastewater Plants (All Plants)
Annual Energy Use (1000's of k
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

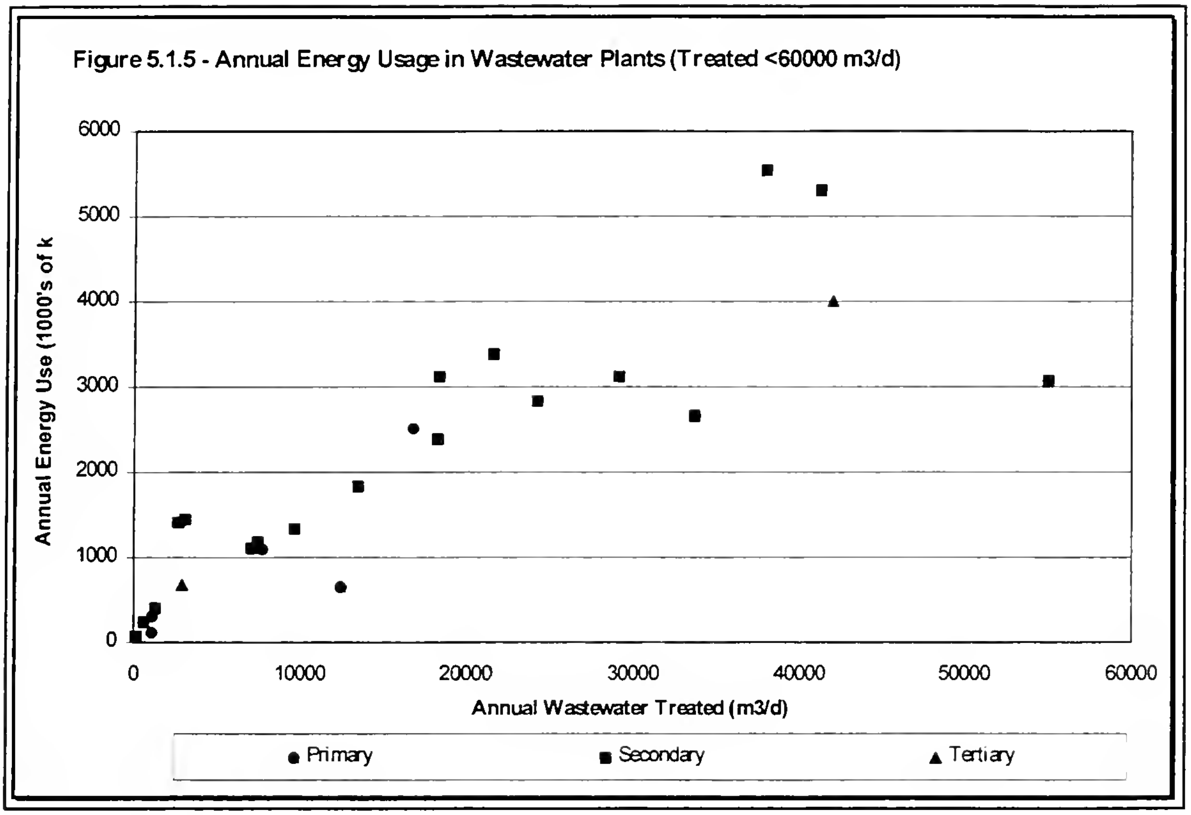


Figure 5.1.5 - Annual Energy Usage in Wastewater Plants (Treated <60000 m3/d)
Annual Energy Use (1000's of k
6000
5000
4000
3000
2000
1000
0
0
10000
20000
30000
40000
50000
60000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

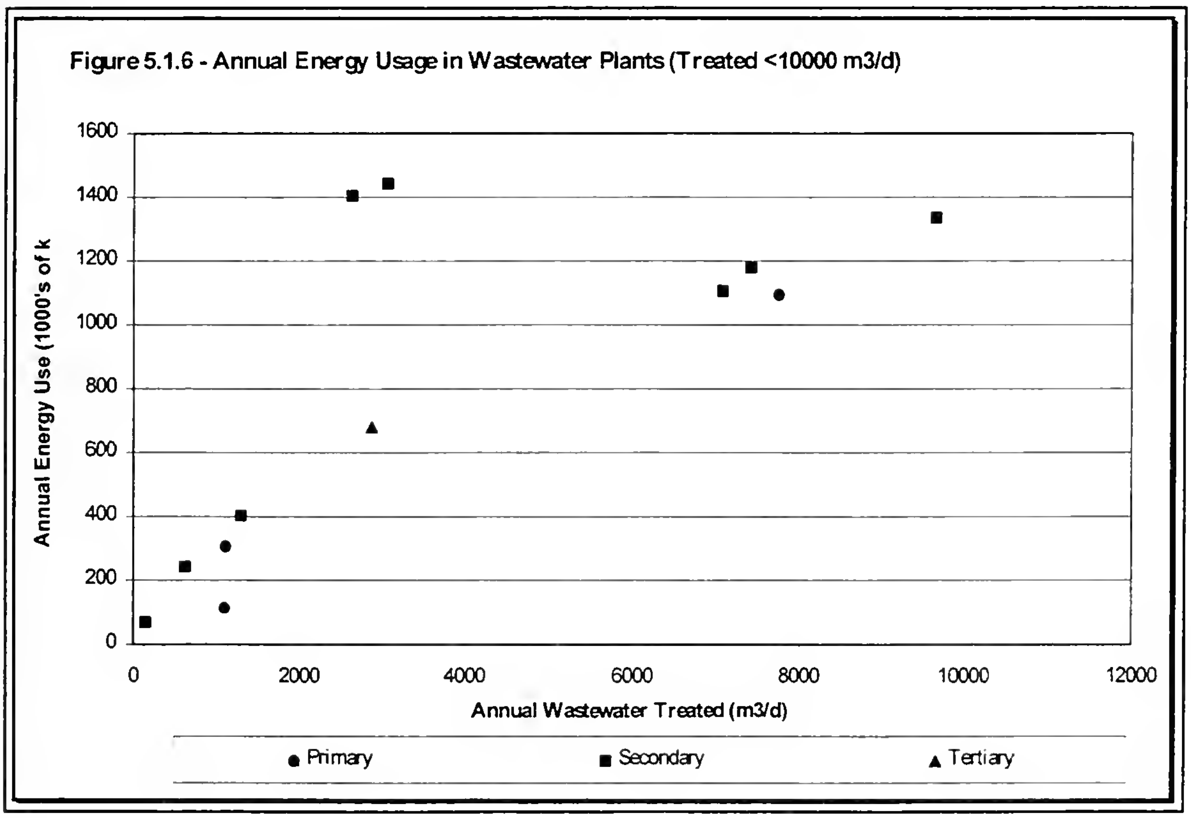


Figure 5.1.6 - Annual Energy Usage in Wastewater Plants (Treated <10000 m3/d)
Annual Energy Use (1000's of k
1600
1400
1200
1000
800
600
400
200
0
0
2000
4000
6000
8000
10000
12000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

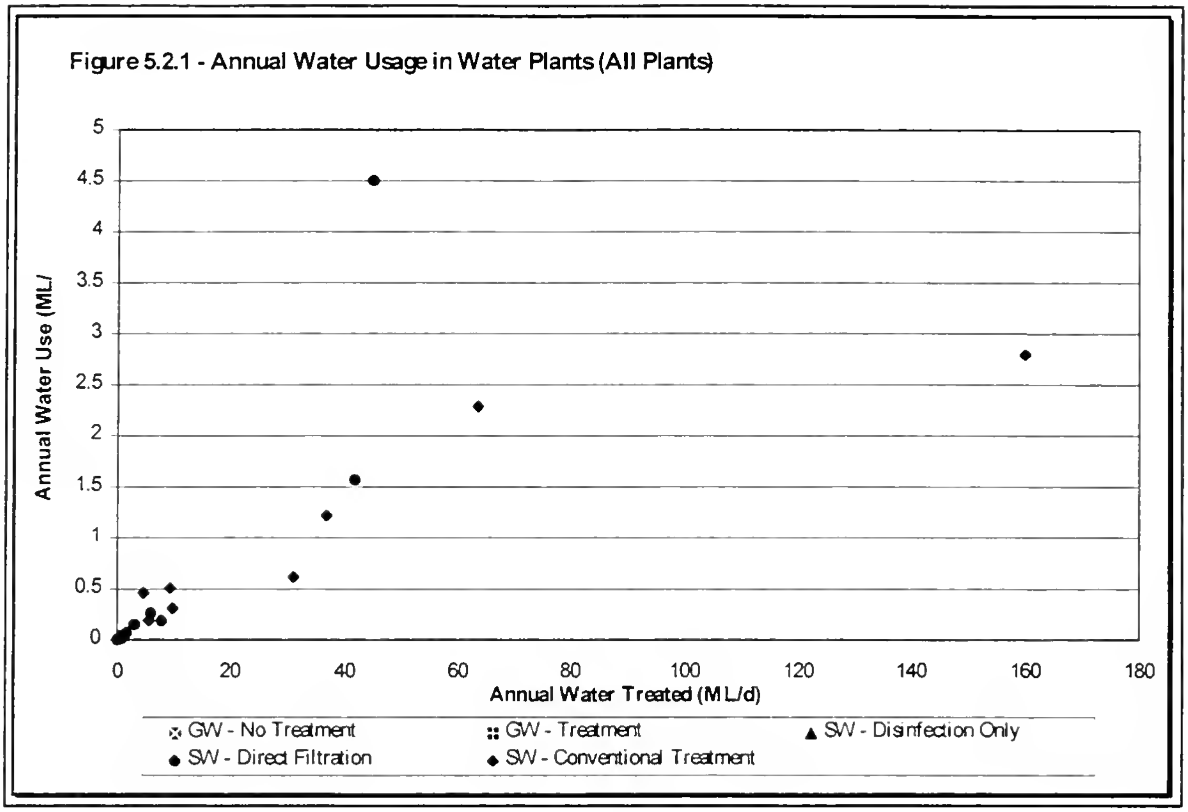


Figure 5.2.1 - Annual Water Usage in Water Plants (All Plants)
Annual Water Use (ML/
Annual Water Treated (ML/d)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
20
40
60
80
100
120
140
160
180
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

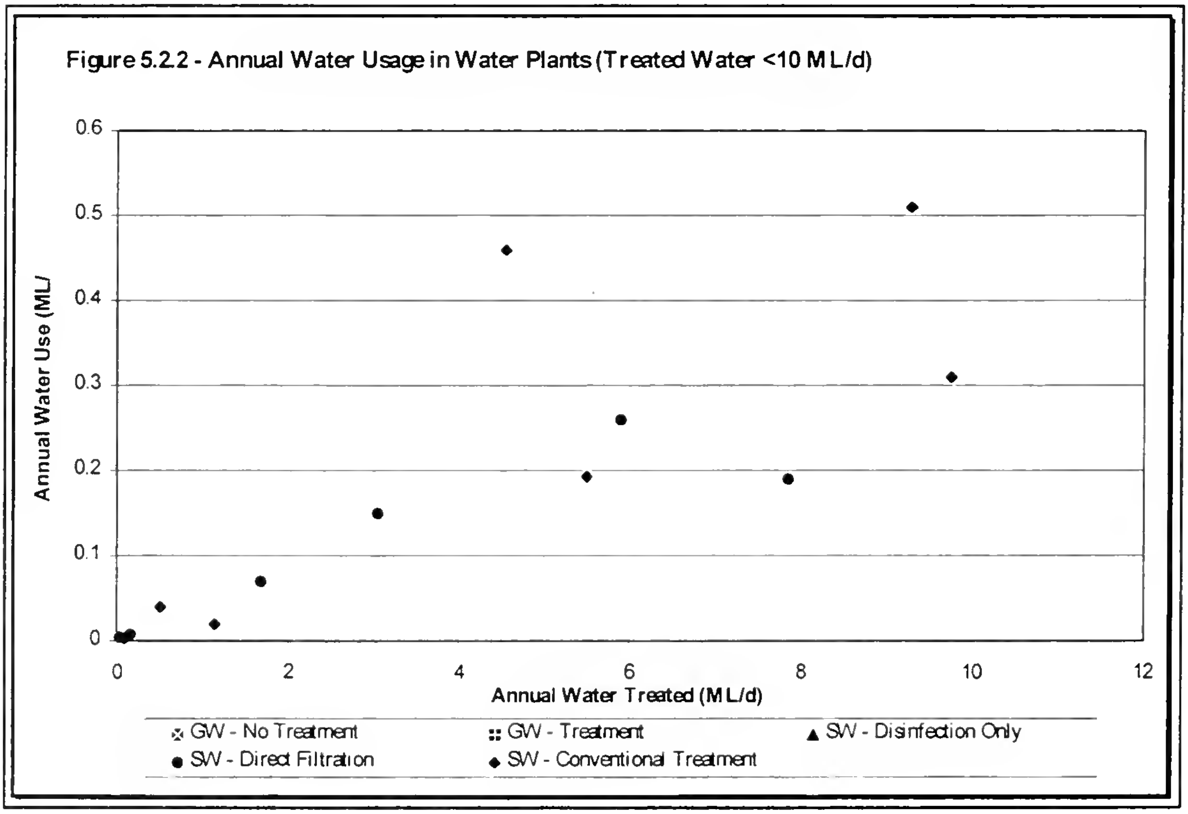


Figure 5.2.2 - Annual Water Usage in Water Plants (Treated Water <10 ML/d)
Annual Water Use (ML/
Annual Water Treated (ML/d)
0
0.1
0.2
0.3
0.4
0.5
0.6
0
2
4
6
8
10
12
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

Figure 5.2.3 - Annual Water Usage in Wastewater Plants (All Plants)

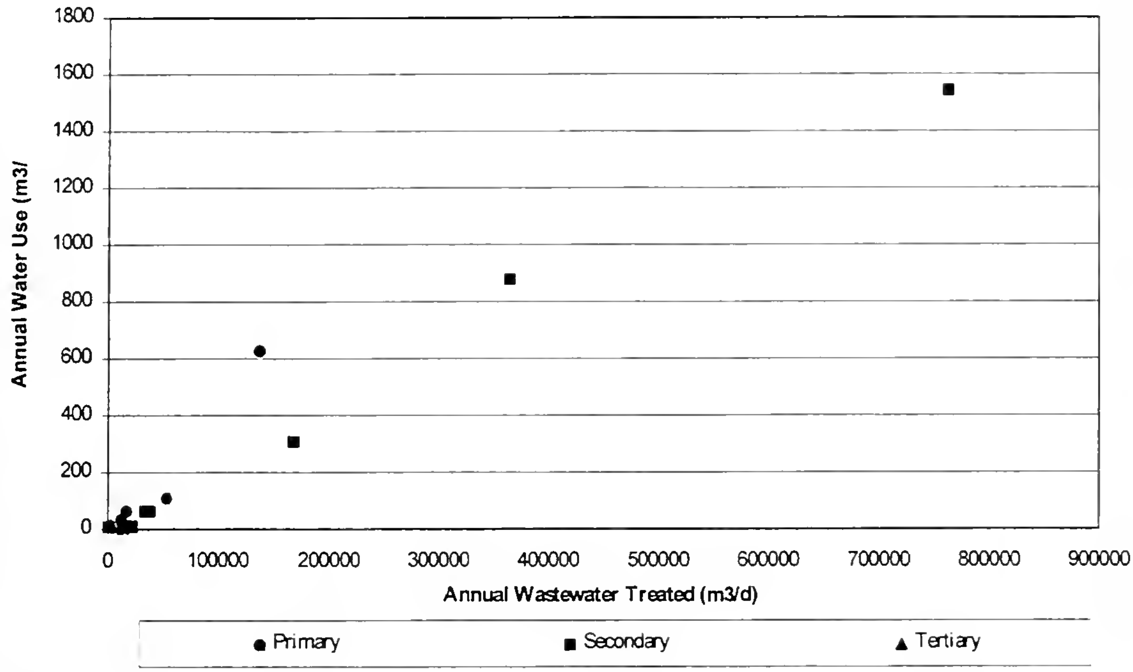
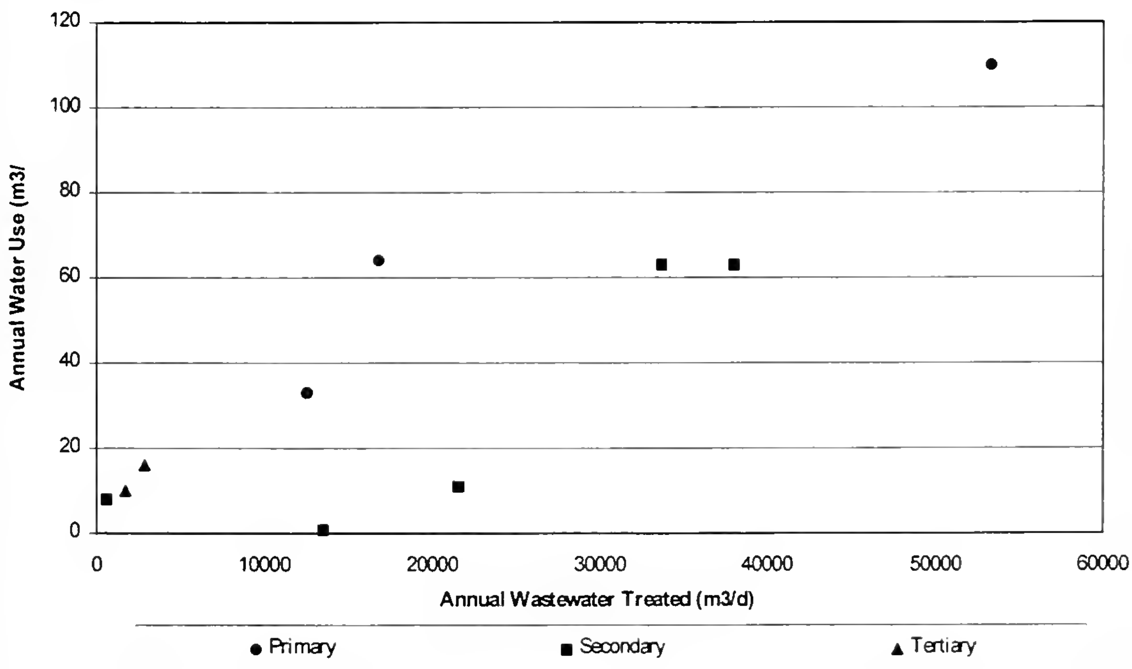


Figure 5.2.4 - Annual Water Usage in Wastewater Plants (Treated<100000m3/d)



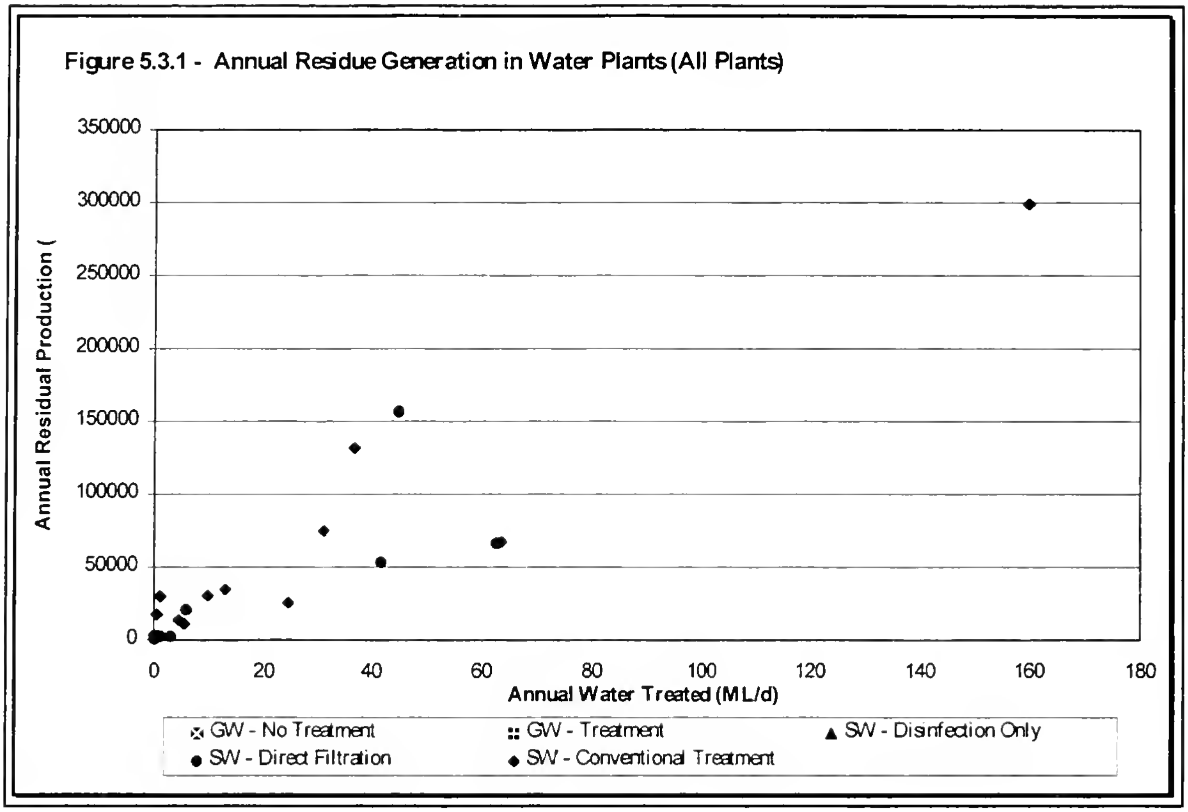


Figure 5.3.1 - Annual Residue Generation in Water Plants (All Plants)
350000
300000
250000
200000
150000
100000
50000
0
Annual Residual Production (
0
20
40
60
80
100
120
140
160
180
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

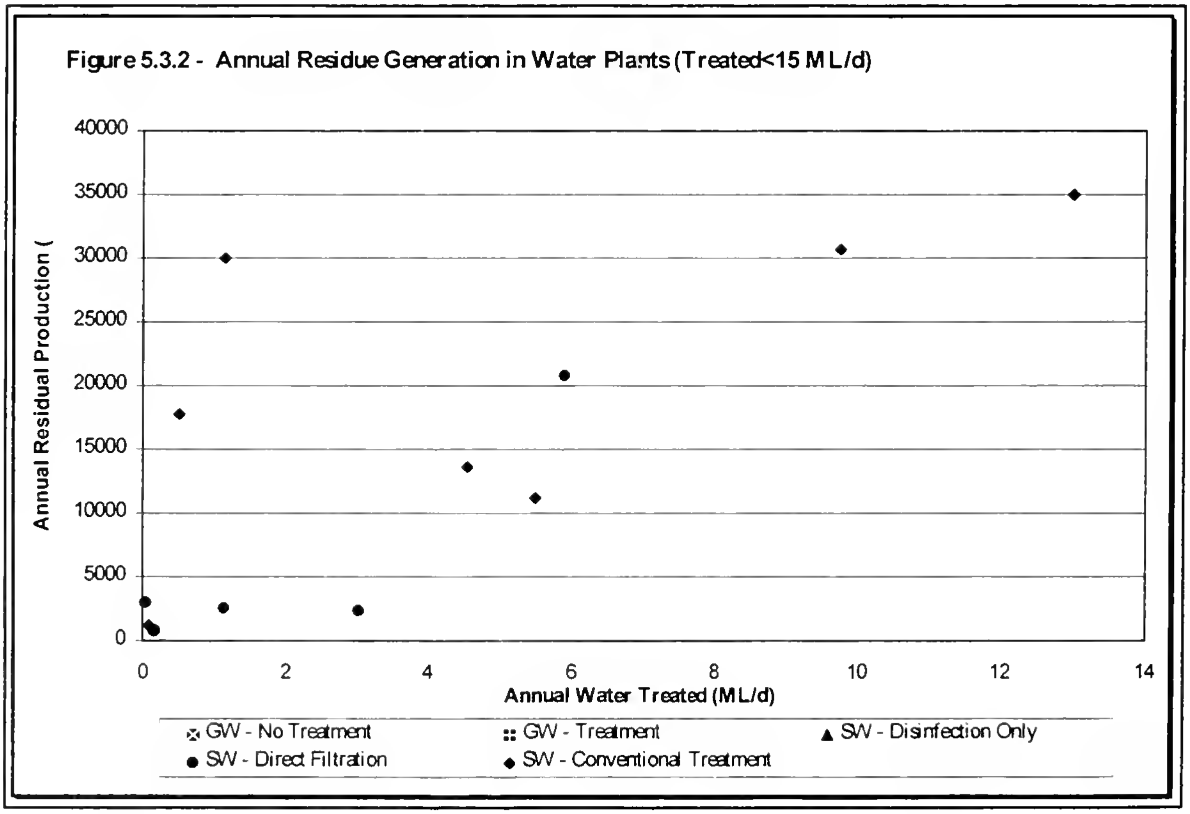


Figure 5.3.2 - Annual Residue Generation in Water Plants (Treated<15 ML/d)
40000
35000
30000
25000
20000
15000
10000
5000
0
Annual Residual Production (
0
2
4
6
8
10
12
14
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

Figure 5.3.3 - Annual Residue Generation in Wastewater Plants (All Plants)

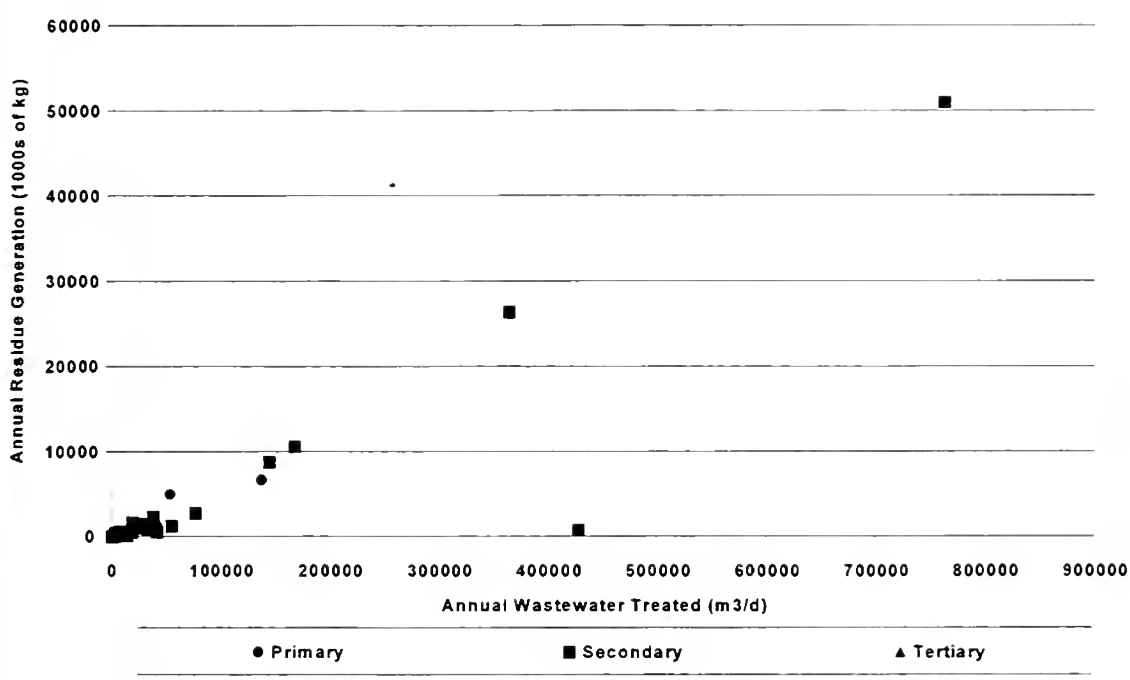
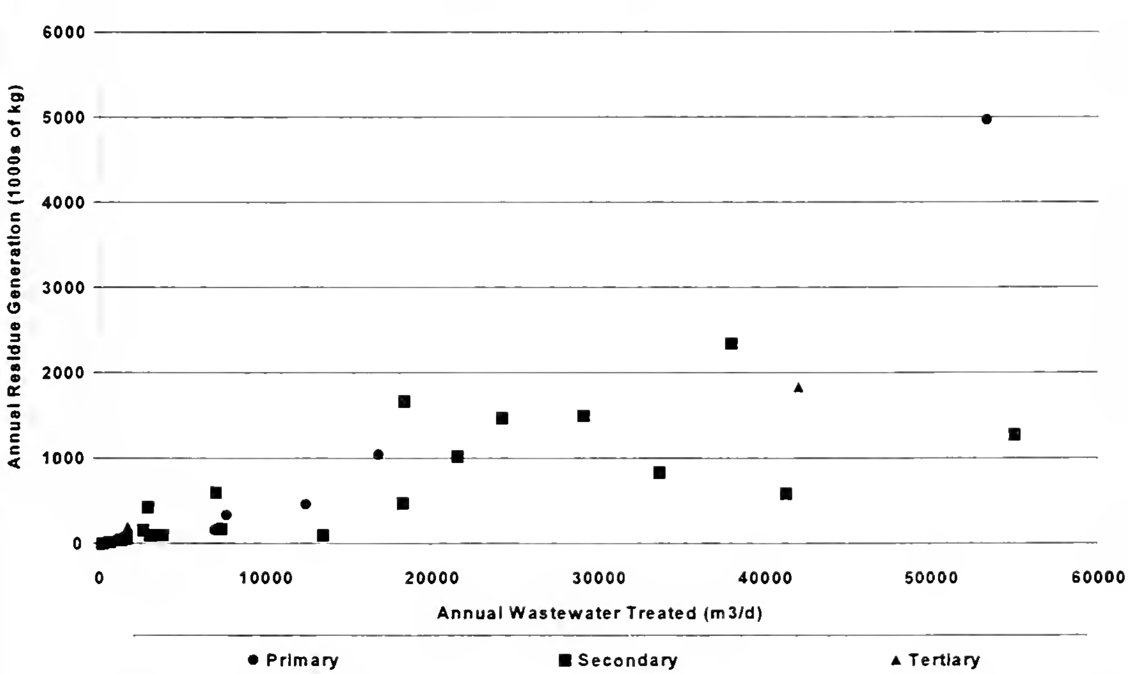


Figure 5.3.4 - Annual Residue Generation in Wastewater Plants (Treated<60000m3/d)



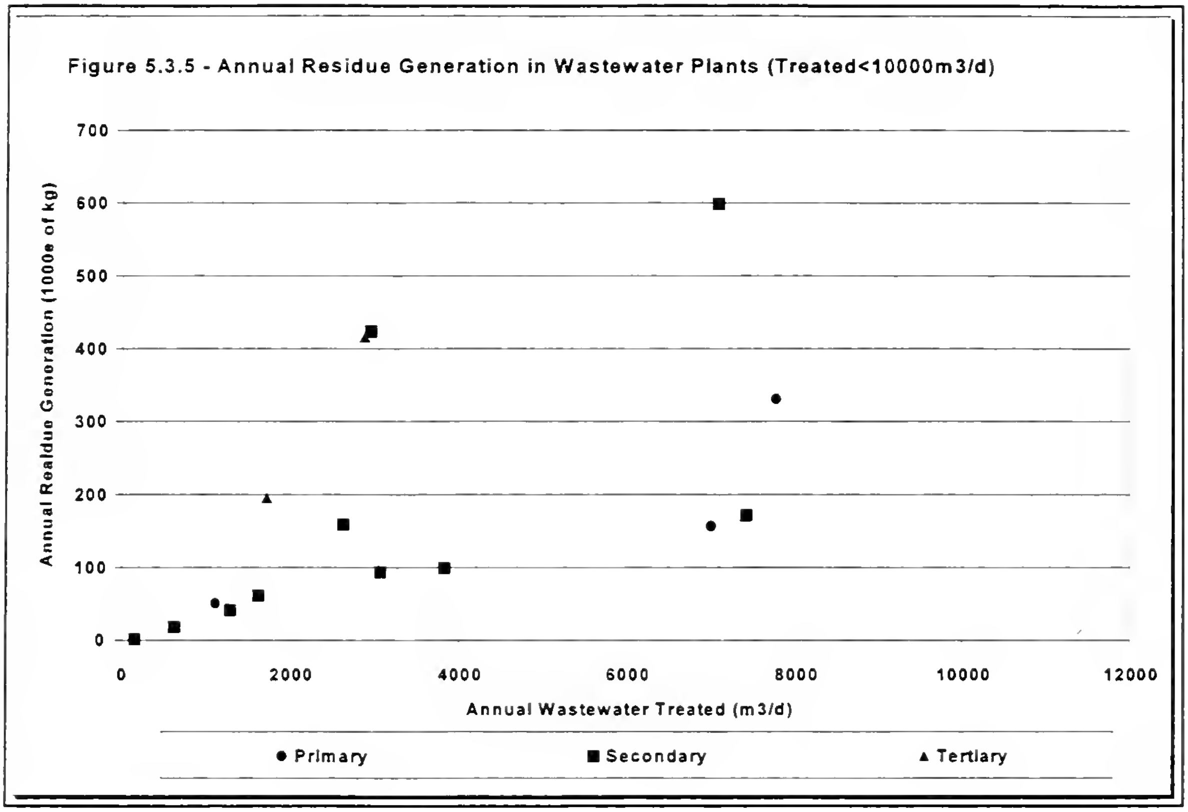


Figure 5.3.5 - Annual Residue Generation in Wastewater Plants (Treated<10000m3/d)
700
600
500
400
300
200
100
0
Annual Residue Generation (1000s of kg)
0
2000
4000
6000
8000
10000
12000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

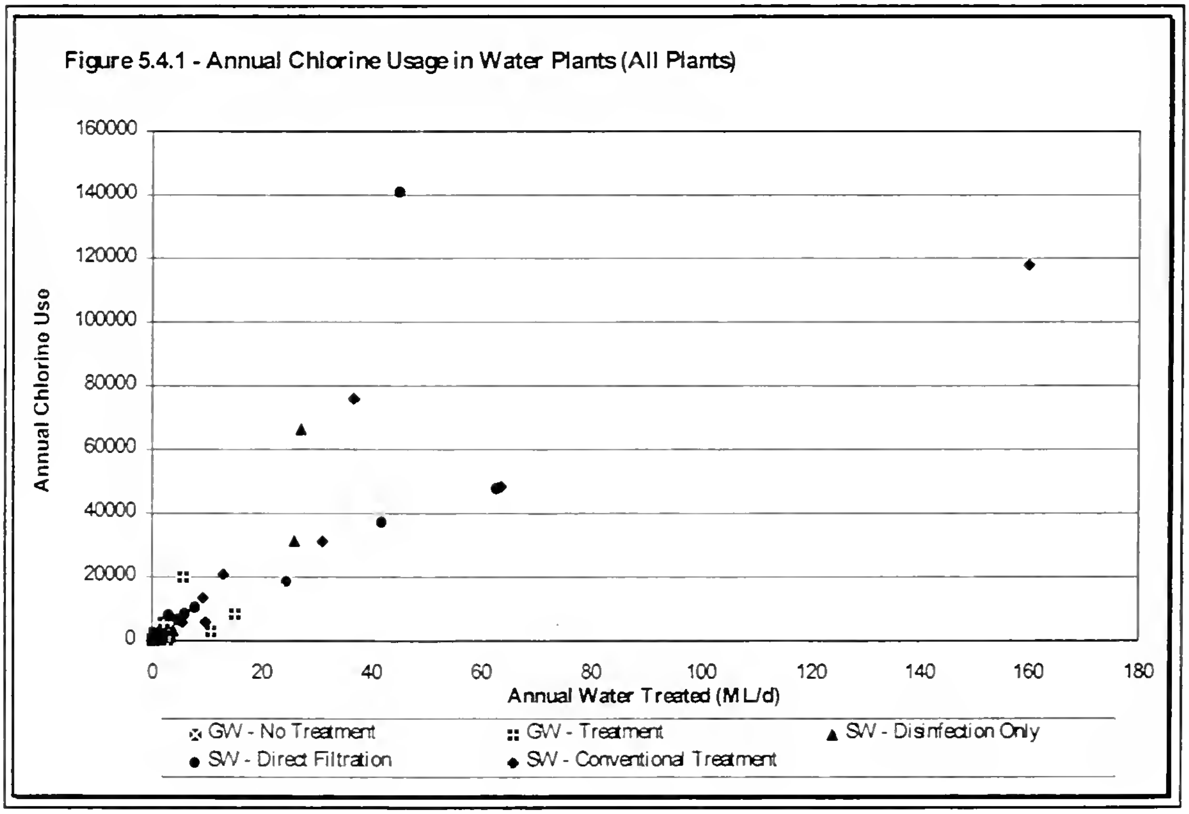


Figure 5.4.1 - Annual Chlorine Usage in Water Plants (All Plants)
160000
140000
120000
100000
80000
60000
40000
20000
0
Annual Chlorine Use
0
20
40
60
80
100
120
140
160
180
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

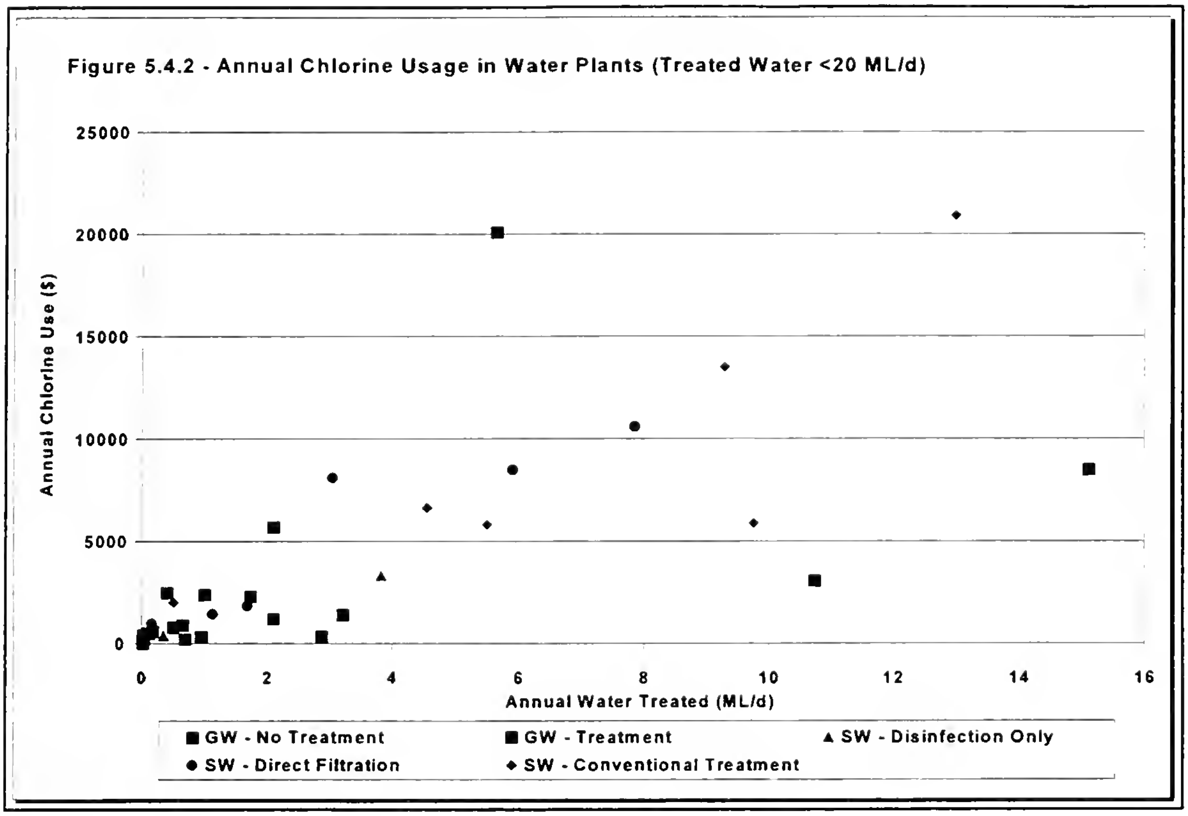


Figure 5.4.2 - Annual Chlorine Usage in Water Plants (Treated Water <20 ML/d)
Annual Chlorine Use ($)
25000
20000
15000
10000
5000
0
0
2
4
6
8
10
12
14
16
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

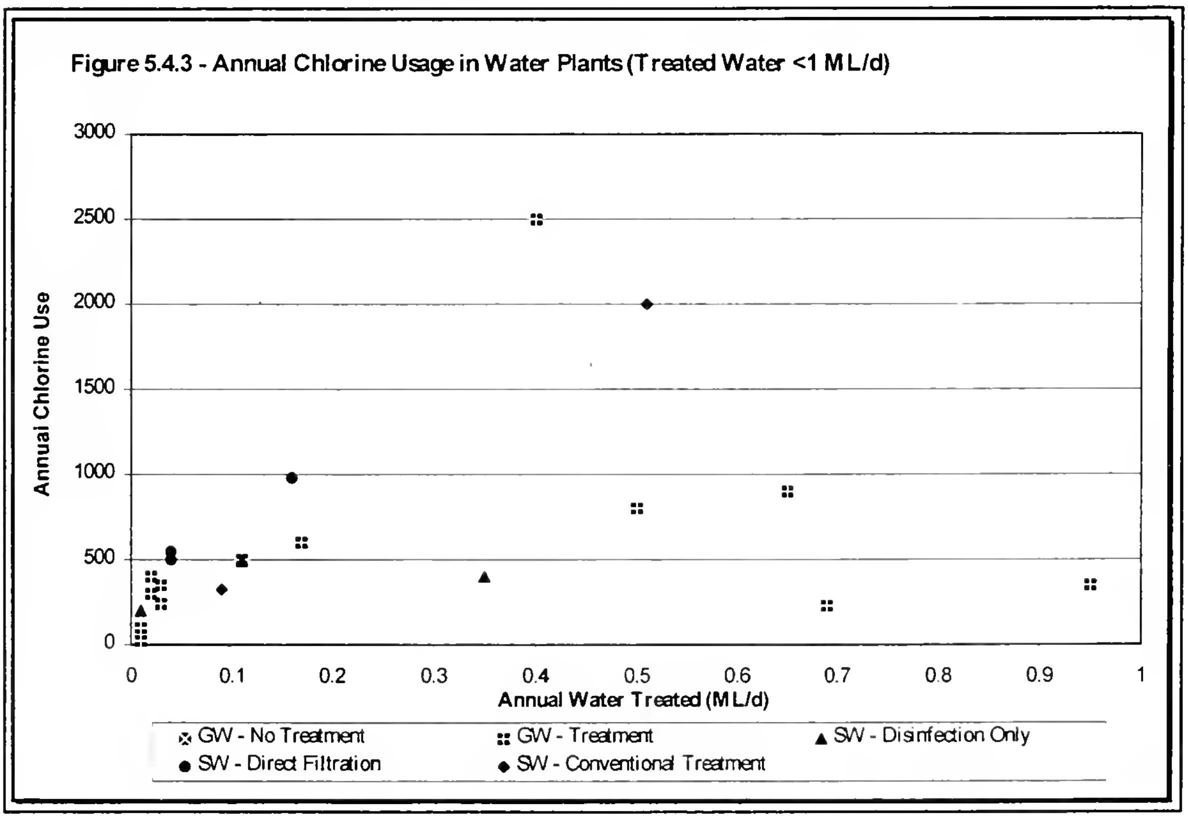


Figure 5.4.3 - Annual Chlorine Usage in Water Plants (Treated Water <1 ML/d)
Annual Chlorine Use
3000
2500
2000
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Annual Water Treated (ML/d)
GW - No Treatment
GW - Treatment
SW - Disinfection Only
SW - Direct Filtration
SW - Conventional Treatment

Figure 5.4.4 - Annual Alum Usage in Water Plants (All Plants)

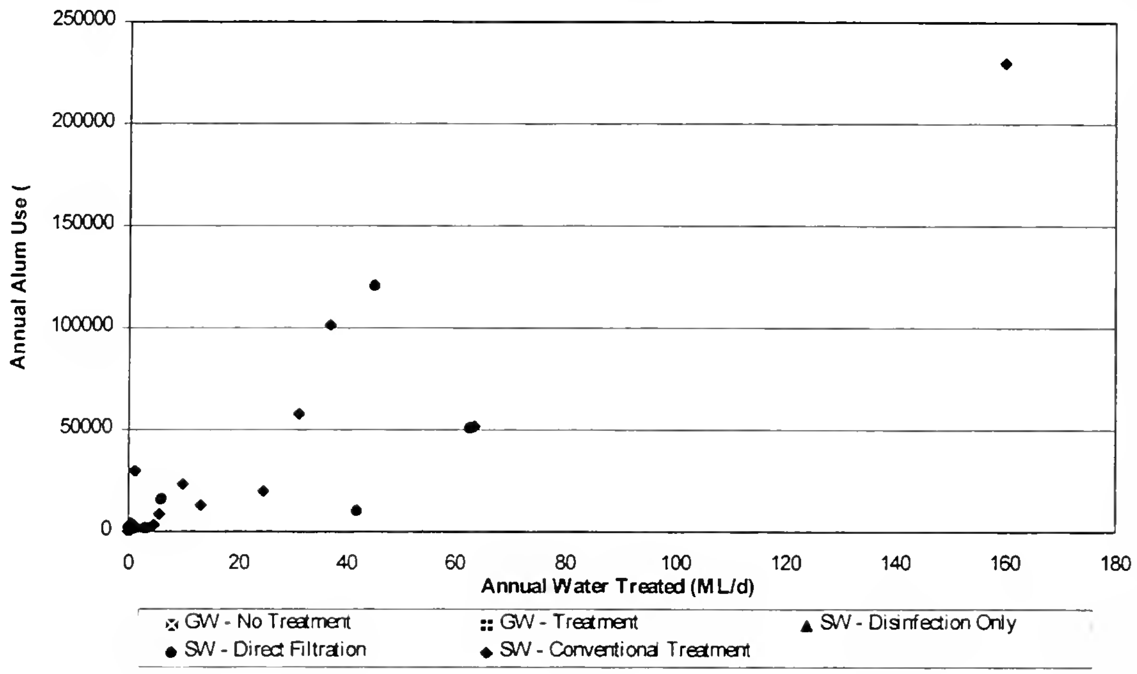


Figure 5.4.5 - Annual Alum Usage in Water Plants (Treated Water <15 ML/d)

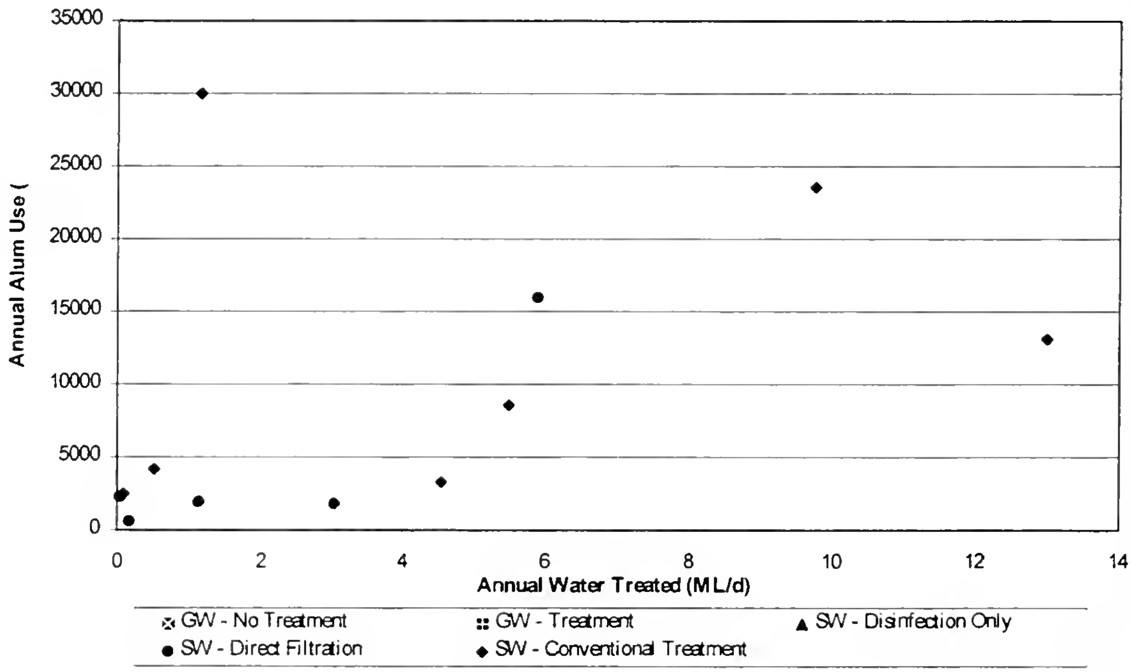


Figure 5.4.6 - Annual Polymer Usage in Water Plants (All Plants)

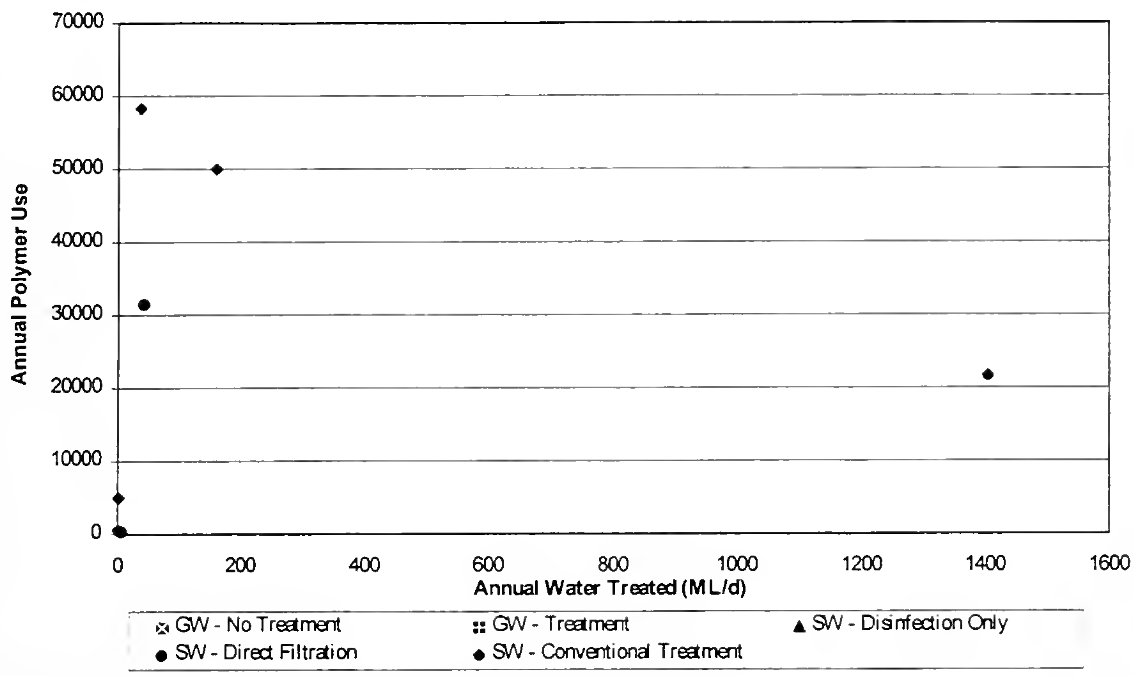
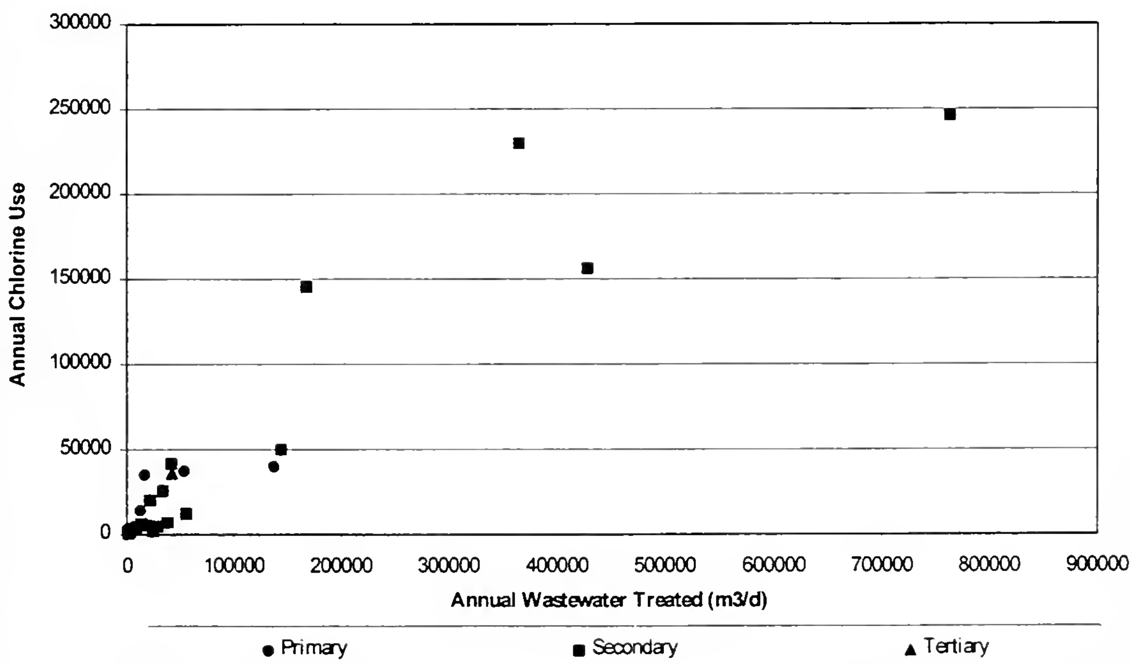


Figure 5.4.7 - Annual Chlorine Usage in Wastewater Plants (All Plants)



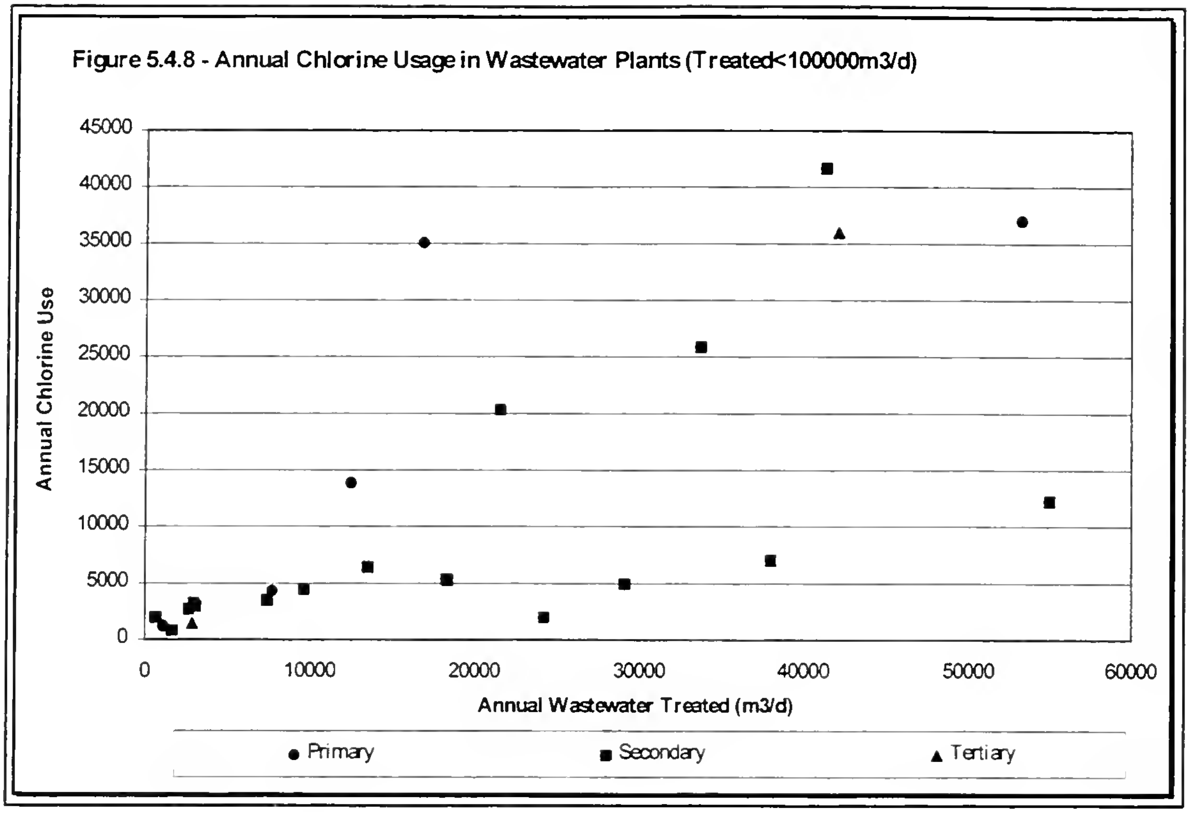


Figure 5.4.8 - Annual Chlorine Usage in Wastewater Plants (Treated<100000m3/d)
Annual Chlorine Use
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
10000
20000
30000
40000
50000
60000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

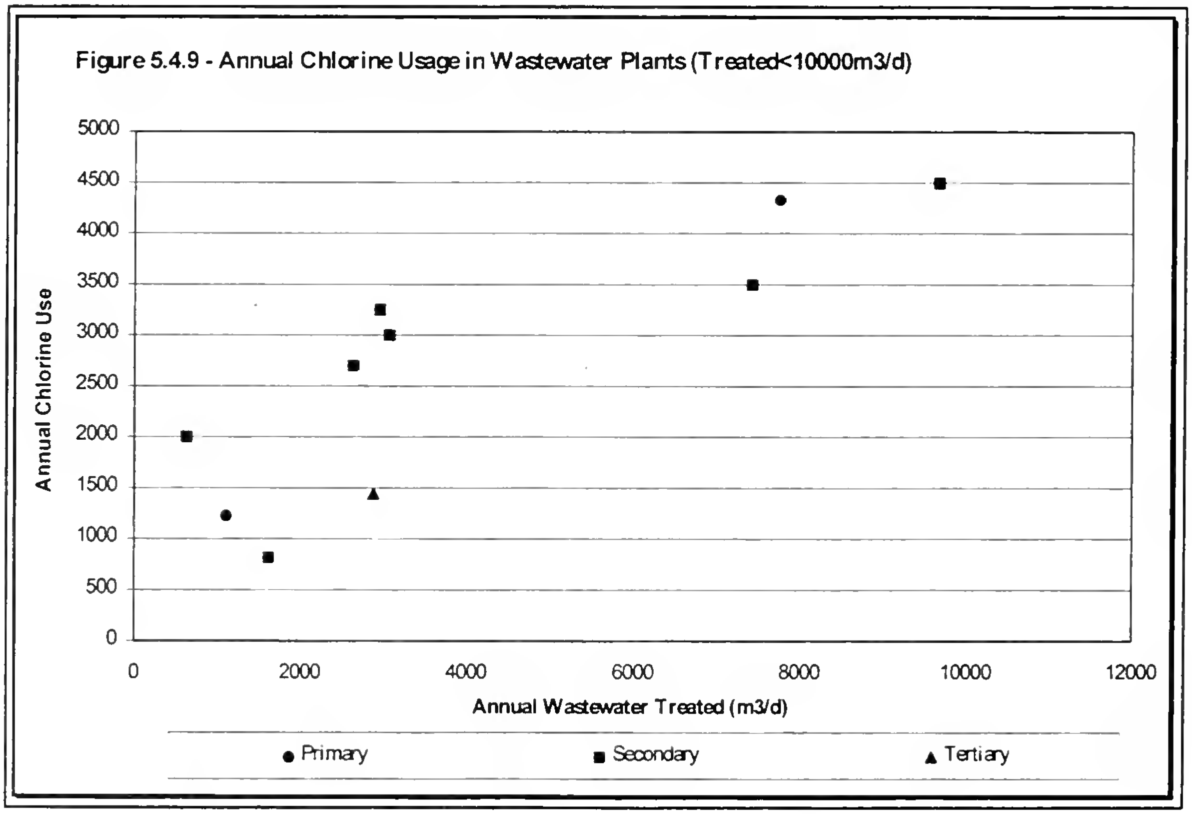


Figure 5.4.9 - Annual Chlorine Usage in Wastewater Plants (Treated<10000m3/d)
Annual Chlorine Use
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2000
4000
6000
8000
10000
12000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

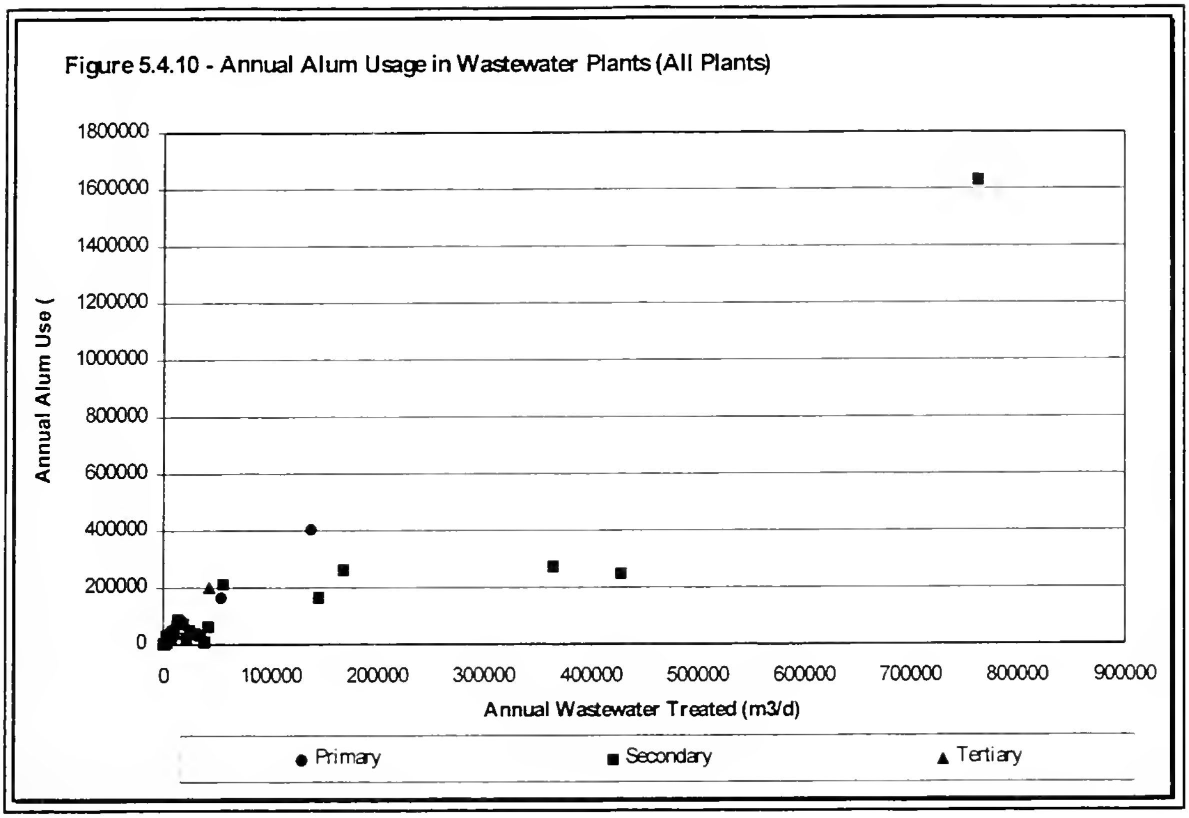


Figure 5.4.10 - Annual Alum Usage in Wastewater Plants (All Plants)
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Annual Alum Use (
0
100000
200000
300000
400000
500000
600000
700000
800000
900000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

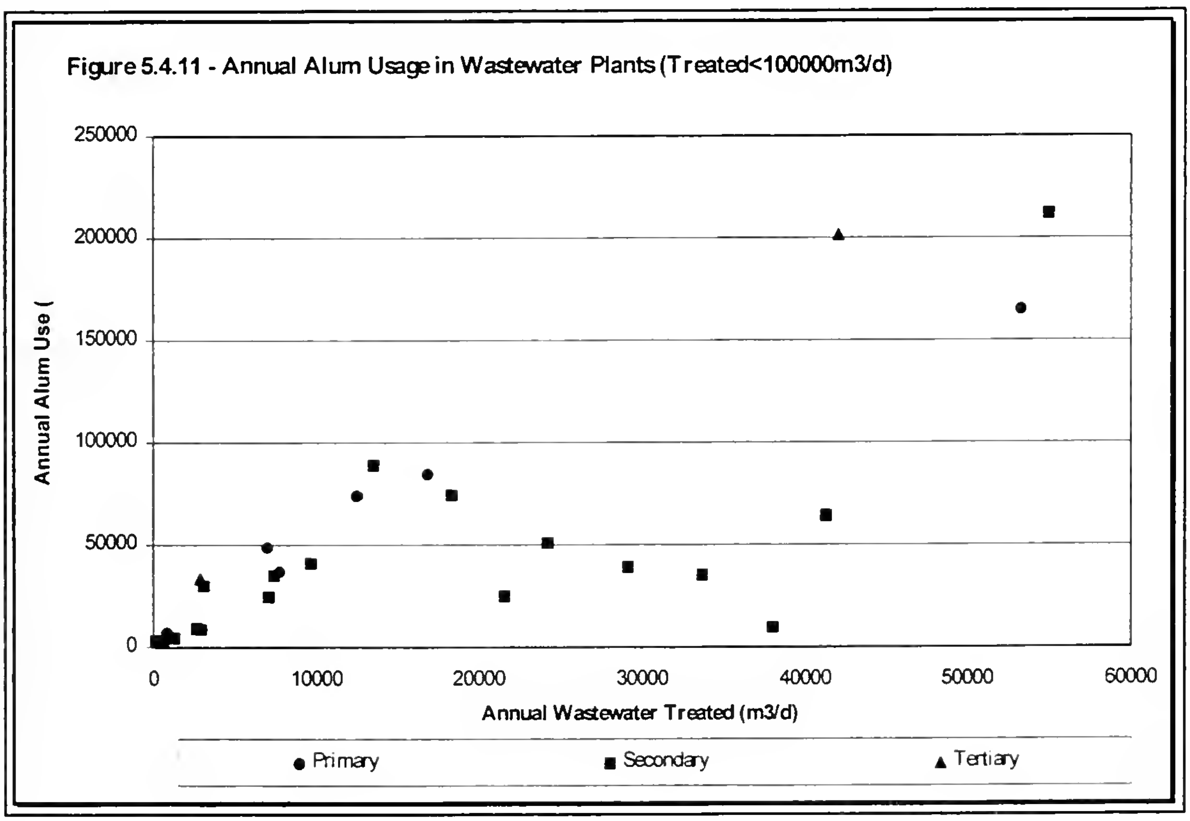


Figure 5.4.11 - Annual Alum Usage in Wastewater Plants (Treated<100000m3/d)
250000
200000
150000
100000
50000
0
Annual Alum Use (
0
10000
20000
30000
40000
50000
60000
Annual Wastewater Treated (m3/d)
Primary
Secondary
Tertiary

Figure 5.4.12 - Annual Alum Usage in Wastewater Plants (Treated<10000m3/d)

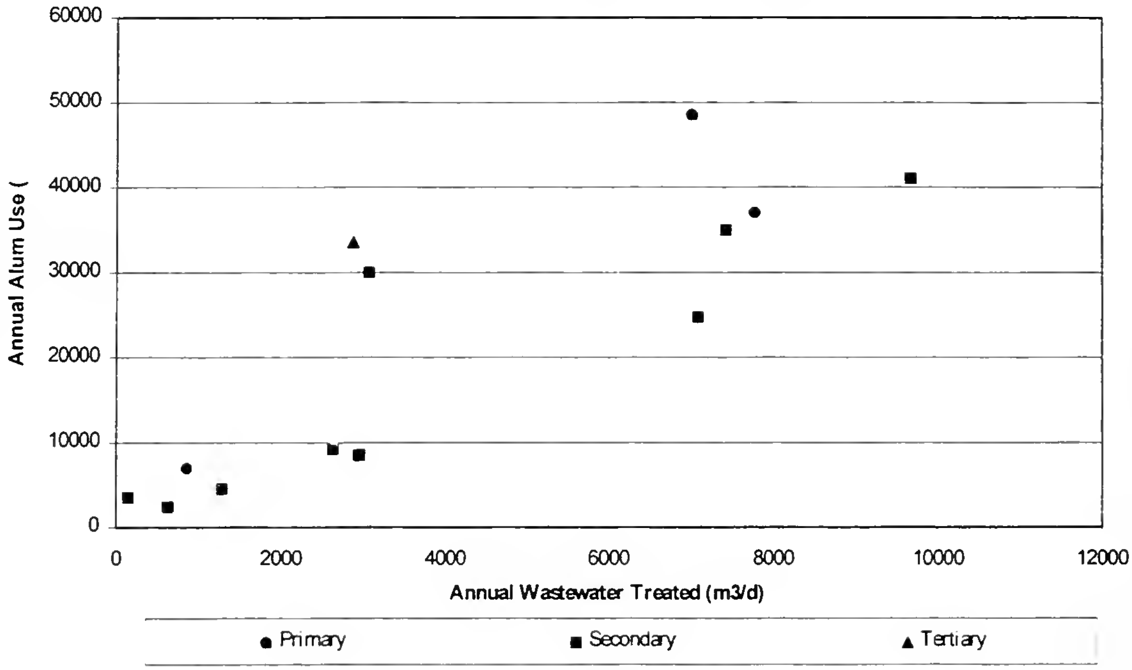


Figure 5.4.13 - Annual Polymer Usage in Wastewater Plants (All Plants)

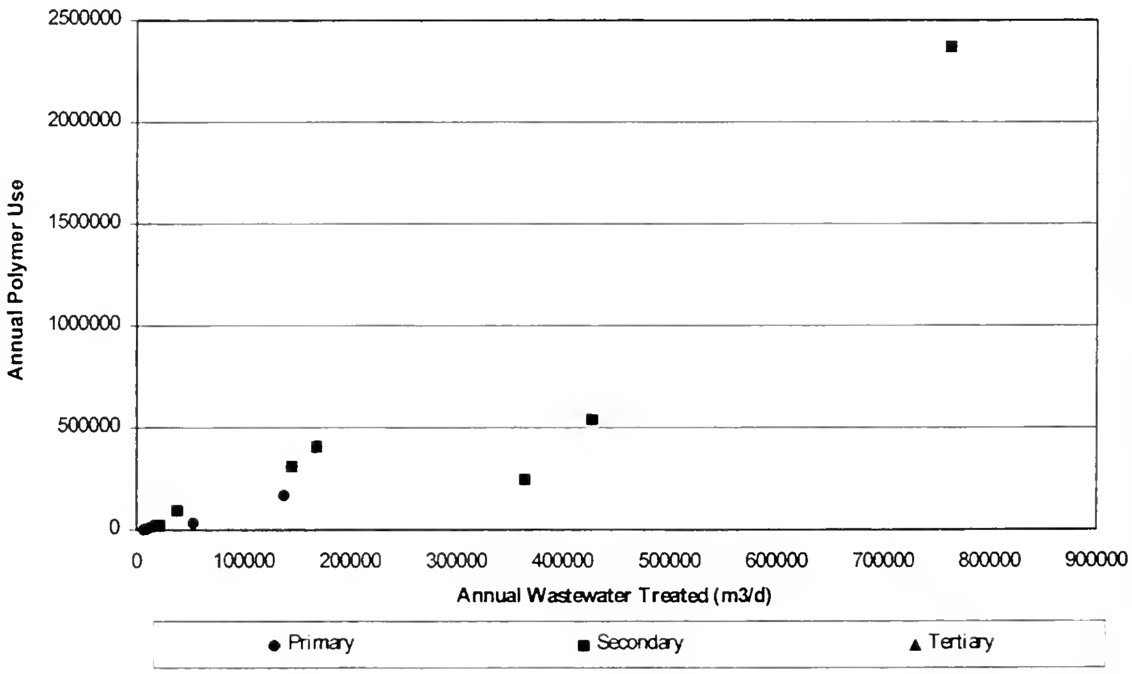
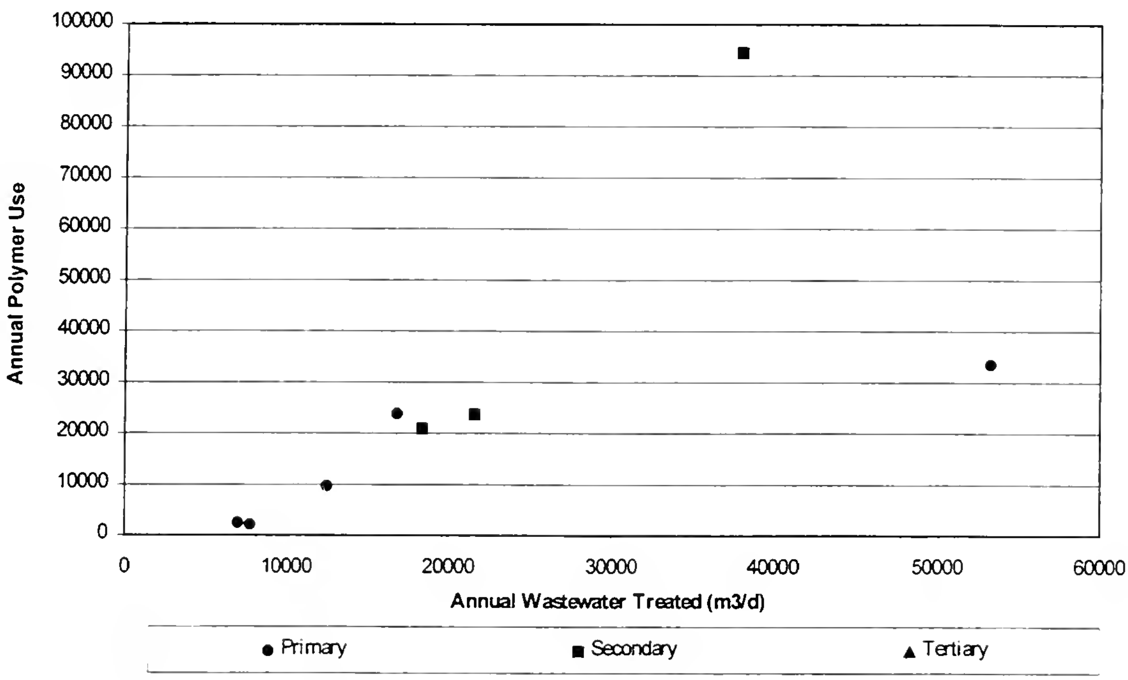


Figure 5.4.14 - Annual Polymer Usage in Wastewater Plants (Treated<100000m3/d)



APPENDIX C
ONTARIO EQUIPMENT SUPPLIERS

APPENDIX C-1

MEMBERS OF ONTARIO WATER WORKS

(Page 109-112)

APPENDIX C-2

MEMBERS OF ONTARIO POLLUTION CONTROL EQUIPMENT ASSOCIATION

(Pages 113 -123)

APPENDIX C-1
MEMBERS OF ONTARIO WATER WORKS ASSOCIATION

A-1 Hydrant Services Ltd.
Unit #18, 550 Coronation Drive
Scarborough, Ontario M1E 4V1

ABB Water Meters Inc.
Unit #35, 1200 Aerowood Drive
Mississauga, Ontario L4W 2S7

Alcan Chemicals
Suite 412, 3-304 Stone Road West
Guelph, Ontario N1G 4W4

Aqua Specialites Ltd.
4153 Blakie Road
London, Ontario N6L 1B9

Badger Daylighting Inc.
#4 236 Braneida Lane, Box 606
Brantford, Ontario N3T 5P9

Bardon Supplies Limited
Box 1023, 31 Wallbridge Cr.
Belleville, Ontario K8N 5B6

Bibby Waterworks Corp.
Box 400, 148 Cross Avenue
Oakville, Ontario L6J 5A8

Bristol Babcock
234 Attwell Drive
Etobicoke, Ontario M9W 5B3

Cambridge Brass
P.O. Box 249, 140 Orion Place
Cambridge, Ontario N1R 5V1

Canada Pipe Company Ltd.
P.O. Box 2849
Hamilton, Ontario L8N 3R5

Canada Valve
101 Webster Road
Kitchener, Ontario N2G 3Y4

Canadian Cement Lining Co. Ltd.
275 Watline Crescent
Mississauga, Ontario L4Z 1P3

Carson's Plumbing Supplies
1071 Goderich St., Box 1820
Port Elgin, Otnario N0H 2C0

Clow Canada
600 Kennilworth Avenue North
Hamilton, Ontario L8N 3R5

Concord Supply
551 Tiffin Street
Barrie, Ontario L4M 4S4

Conval Equipment Ltd.
Unit 39-111 Finch Avenue West
Downsview, Ontario M3J 2E5

Coulter Water Meter Service Inc.
P.O. Box 216
Strathroy, Ontario N7G 3J2

Cromer Industries Corporation
961 Tiffany Circle
Oshawa, Ontario L1G 7S1

MEMBERS OF ONTARIO WATER WORKS ASSOCIATION

Denso North America Inc.
Unit 3, 75 Shields Court
Markham, Ontario L3R 9T4

Devine & Associates Ltd.
210 Don Park Road, Unit 11
Markham, Ontario L3R 2V2

Direct Equipment Ltd.
Box 115, 1363 Cornwall Road
Oakville, Ontario L6J 4Z5

Duraton Systems Ltd.
120 Melford Drive, Unit 9
Scarborough, Ontario M1B 2X5

Ecodyne Limited
2201 Speers Road
Oakville, Ontario L6L 2X9

Emco Supply
65 Huxley Road
Weston, Ontario M9M 1H5

Evans Utility & Municipal Products Supply Ltd.
396 Neptune Crescent
London, Ontario N6M 1A2

Fabtech Fabricated Technologies Inc.
106 Healey Road
Bolton, Ontario L7E 5R2

Fryston Canada Incorporated
7370 Bramalea Road, Suite 30
Mississauga, Ontario L5S 1N6

Greatario Industrial Storage Systems Ltd.
P.O. Box 3613
Guelph, Ontario N1H 6P1

Heath Consultants Ltd.
2085 Piper Lane
London, Ontario N5V 3M5

Hyperscon Inc.
#35, 3075 Ridgeway Drive
Mississauga, Ontario L5L 5M6

IPEX Pipe
6810 Invader Crescent
Mississauga, Ontario L5T 2B6

ITT Flyght
108 Skyway Avenue
Etobicoke, Ontario M9W 4Y9

International Water Supply Ltd.
P.O. Box 310, 342 Bayview Drive
Barrie, Ontario L4M 4T5

Lafarge Pressure Pipe
5387 Bathesda Road
Stouffville, Ontario L4A 7X3

APPENDIX C-1
MEMBERS OF ONTARIO WATER WORKS ASSOCIATION

Liphook Couplers & Ontario Excavac
4225 Hickory Drive
Mississauga, Ontario L4W 1L3

Lisle-Metrix Ltd.
49 Sheffield Street
Toronto,Ontario M6M 3E5

Lotowater Ltd.
P.O. Box 451, 149 Golf Links Road
Paris, Ontario N3L 3T5

Maple Agencies
Unit 25, 8461 Keele Street
Concord, Ontario L4A 5Z8

Millennium Control Company
P.O. Box 86034, Upper Oakville
Oakville, Ontario L6H 5V6

Mueller Canada
8069 Lawson Road
Milton, Ontario L9T 4B6

Napier-Reid Ltd.
10 Alden Road, Unit 2
Markham, Ontario L3R 2S1

Ontario Water Products Inc.
4102 Eastage Crescent
London, Ontario N6L 1B2

Owl-lite Rentals & Sales/Ontario Laser Rentals
71 Steinway Blvd.
Etobicoke, Ontario M9W 6H6

Power Plant Supply Co.
124 Wilson Street
Oakville, Ontario L6K 3G8

REHAU Industries Inc.
1149 Pioneer Road
Burlington, Ontario L7M 1K5

Les Produits Industriels Robar Inc.
12945-78th Avenue
Surrey, B.C., V3W 2X8

Royal Pipe Company
55 Regalcrest Court
Woodbridge, Ontario L4L 8P3

Samson Valve & Meter Inc.
RR#5 Maitland Drive
Belleville, Ontario K8N 4Z5

Schlumberger Industries
7275 West Credit Avenue
Mississauga, Ontario L5N 5M9

Sensus Technologies (RGE Inc.)
3600 Delson Drive
Navan, Ontario K4B 1K5

Sewer-Matic Services
4140 Belgreen Drive
Gloucester, Ontario K1G 3N2

Sigma-Mag Canada
8461 Keele Street, Unit 25
Concord, Ontario L4A 5Z8

Summa Engineering Ltd.
6423 Northam Drive
Mississauga,Ontario L4V 1J2

Syntec Process Equipment Ltd.
Unit 1, 68 Healey Road
Bolton, Ontario L7E 5A4

Trenchless Utility Equipment Inc.
960 Zelco Drive
Burlington, Ontario L7L 4Y3

Universal Flow Engineering Inc.
1860 Matena Avenue
Mississauga, Ontario L5J 1G3

Urecon Limited
#206-2601 Matheson Blvd. East
Mississauga,Ontario L4W 5A8

C.R. Wall & Co.
Box 578, 2611 Development Drive,
Unit 8
Brockville, Ontario K6V 5V7

Wamco Inc.
551 Tiffin Street, RR#2
Barrie, Ontario L4M 4S4

Appendix C-2
Members of Ontario Pollution Control Equipment Association

ABBA Parts & Service
5370 Munro Court
Burlington, Ontario L7L 5N8
Phone: (905) 333-2720
Fax: (905) 333-0973

ABS Pumps Corporation
1215 Meyerside Drive, Unit #7
Mississauga, Ontario L5T 1H3
Phone: (905) 670-4677
Fax: (905) 670-3709

ACO Container Systems
794 Mckay Road
Pickering, Ontario L1W 2Y4
Phone: 1-800-542-9942
Fax: 1-800-542-4722

ADI Systems Inc.
1133 Regent St., Suite 300
Fredericton, NB E3B 3Z2
Phone: (506) 452-7303or
1-800-561-BVFI

Alfa Laval Separation
Sharples Centrifuges
101 Milner Avenue
Scarborough, Ontario M1S 4S6
Phone: (416) 297-6345

Anachemia Science
6535 Mill Creek Dr., Unit 69
Mississauga, Ontario L5N 2M2
Phone: (905) 567-8292 or
1-800-387-8106

Aquablast Corporation
77 Orchard Road
Ajax, Ontario L1S 6K9
Phone: (905) 619-3009
Fax: (905) 619-3638

Aquatronix Inc.
70 Gibson Dr., Unit #8
Markham, Ontario L3R 4C2
Phone: (905) 475-8082
Fax: (905) 475-1616

Arbrux Limited
P.O.Box 611, 10 Douglas Rd.
Uxbridge, Ontario L9P 1N1
Phone: (905) 852-5417
Fax: (905) 852-5625

Ajax
2495 Haines Rd.
Mississauga, Ontario L4Y 1Y7
Phone: (905) 276-2208 or
1-800-387-9487

Armour Valve Ltd.
455 Milner Ave., Unit 10
Scarborough, Ontario M1B 2K4
Phone: (416) 299-0780
Fax: (416) 299-0394

Barringer Laboratories Ltd.
5735 McAdam Rd.
Mississauga, Ontario L4Z 1N9
Phone: (905) 890 8566 or
1-800-263-9040

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Baypark Environmental Inc.
1175 Appleby Line, Unit C-3
Burlington, Ontario L7L 5H9
Phone: (905) 332-5040
Fax: (905) 332-5044

Belzona Ontario Inc.
P.O Box 10007, 35 E.P. Lee Dr.
Bracebridge, Ontario P1L 1W6
Phone: (705) 645-5122
Fax: (705) 645-7954

BNW Valve Manufacturing Ltd.
P.O.Box 47
Millgrove, Ontario L0R 1V0
Phone: (905) 689-4713
Fax: (905) 689-7402

Bristol Babcock
234 Attwell Dr.
Rexdale, Ontario M9W 5B3
Phone: (416) 675-3820
Fax: (416) 674-5129

John Brooks Company Ltd.
1260 Kamato Road
Mississauga, Ontario L4W 1Y1
Phone: (905) 624-5757
Fax: (905) 624-1799

C&M Environmental
P.O. Box 122
Midhurst, Ontario L0L 1X0
Phone: (705) 726-1942
Fax: (705) 726-1962

Canadian Drives Inc.
40 Claireville Drive
Etobicoke, Ontario M9W 5T9
Phone: (416) 213-1022
Fax: (416) 213-0821

Canadian Liquid Air
351 Eleanor Street
London, Ontario N5W 6B7
Phone: (519) 455-3990
Fax: (519) 455-3828

Canadian Safety Equipment Inc.
2465 Cawthra Road, Unit 111
Mississauga, Ontario L5A 3P2
Phone: (905) 949-2741 or
1-800-265-0182

Can-Am Instruments Ltd.
2495 Haines Rd.
Mississauga, Ontario L4Y 1Y7
Phone: (905) 277-0331
Fax: (905) 277-2588

CD Nova-Tech Inc.
275 Renfrew Dr., Suite 201
Markham, Ontario L3R 0C8
Phone: (905) 940-8338
Fax: (905) 940-6659

Chemline Plastics Ltd.
55 Guardsman Road
Thornhill, Ontario L3T 6L2
Phone: (905) 889-7890
Fax: (905) 889-8553

Appendix C-2
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CMS Group Inc.
185 Snow Blvd., Suite 200
Concord, Ontario L4K 4N9
Phone: (905) 660-7580 or
(416) 447-4964

Dalitek Inc.
6580 Davand Dr., Unit 4
Mississauga, Ontario L5T 2M3
Phone: (905) 795-8841
Fax: (905) 795-9141

Degremont Infilco Ltd.
4145 North Service Rd., Suite 200
Burlington, Ontario L7L 6A3
Phone: (905) 332-2322
Fax: (905) 332-3007

Eaglebrook, Inc. of Canada
100 MacIntosh Blvd.
Concord, Ontario L4K 4P3
Phone: (905) 761-6361
Fax: (905) 761-6366

Ecodyne Limited
2201 Speers Rd.
Oakville, Ontario L6L 2X9
Phone: (905) 827-9821
Fax: (905) 827-8428

Eimco Process Equipment
362 Grenville Avenue
Orillia, Ontario L3V 7P7
Phone: (705) 325 0342
Fax: (705) 325-4296

Dagex Inc.
9030 Leslie St., Unit 5
Richmond Hill, Ontario L4B 1G2
Phone: (905) 771-8400
Fax: (905) 771-8911

Davis Controls Ltd.
2200 Bristol Circle
Oakville, Ontario L6H 5R3
Phone: (905) 829-2000
Fax: (905) 829-2630

DeZurik of Canada
385 Franklin Blvd.
Cambridge, Ontario N1R 5V5
Phone: (519) 621-8980
Fax: (519) 621-9521

Eckel Industries of Canada Ltd.
P.O.Box 776, 100 Allison Ave.
Morrisburg, Ontario K0C 1X0
Phone: (613) 543-2967
Fax: (613) 543-4173

Eco Process & Equipment Inc.
3330 Des Enterprises Blvd.
Terrebonne, QC J6X 4J8
Phone: (514) 477-7879 or
1-800-301-8248

Elsag Bailey (Canada) Inc.
134 Norfinch Drive
Toronto, Ontario M3N 1X7
Phone: (416) 667-9800
Fax: (416) 667-8469

Envirocan Wastewater Treatment Equipment Co. Ltd.
26 McCauley Drive
Bolton, Ontario L7E 5R8
Phone: (905) 880-2418

EV Environmental Systems Ltd.
1175 Appleby Line, Unit B2
Burlington, Ontario L7L 5H9
Phone: (905) 335-8944
Fax: (905) 335-8972

F.E. Myers Company
269 Trillium Drive
Kitchener, Ontario N2G 4W5
Phone: (519) 748-5470
Fax: (519) 748-2553

Ford Hall Company Inc.
P.O. Box 54312
Lexington, KY 40555
Phone: (606) 624-1077
Fax: (606) 624-3320

Fryston Canada Inc.
7370 Bramalea Rd., Suite 30
Mississauga, Ontario L5S 1N6
Phone: (905) 612-0566
Fax: (905) 612-0575

General Signal Pump Group
871 Victoria North, #201
Kitchener, Ontario N2B 3S4
Phone: (519) 743-4575
Fax: (519) 743-4423

Environmental Science & Engineering Magazine
220 Industrial Pkwy. S., Unit 30
Aurora, Ontario L4G 3V6
Phone: (905) 727-4666

Fabricated Plastic Ltd.
2175 Teston Road
Maple, Ontario L6A 1T3
Phone: (905) 832-8161
Fax: (905) 832-2111

FMC of Canada Limited
30 Royal Crest, Unit 11
Markham, Ontario L3R 9W8
Phone: (905) 474-7522
Fax: (905) 474-7542

Frontenac Environmental Ltd.
6 Bram Court
Brampton, Ontario L6W 3R6
Phone: (905) 457-5145
Fax: (905) 457-1730

GEA Process Technology Canada Inc.
5353 John Lucas Drive
Burlington, Ontario L7L 6G5
Phone: (905) 319-3900

GL&V Ontario Inc.
174 West St. S.
Orillia, Ontario L3V 6L4
Phone: (705) 325-6181
Fax: (705) 325-3363

Appendix C-2
Members of Ontario Pollution Control Equipment Association

Gorman-Rupp of Canada Ltd.
70 Burwell Road
St. Thomas, Ontario N5P 3R7
Phone: (519) 631-2870
Fax: (519) 631-4624

Greey Lightnin
100 Miranda Avenue
Toronto, Ontario M6B 3W7
Phone: (416) 781-6105
Fax: (416) 781-0354

Hayward Gordon Limited
6660 Campobello Road
Mississagua,Ontario L5N 2L9
Phone: (905) 567-6116
Fax: (905) 567-1706

Hibon Inc.
850 Legion Rd., Unit 3
Burlington, Ontario L7S 1T5
Phone: (905) 681-7712
Fax: (905) 681-1544

Hoskin Scientific Limited
4210 Morris Drive
Burlington, Ontario L7L 5L6
Phone: (905) 333-5510
Fax: (905) 333-4976

Hydro-Logic Environmental
3017 St. Clair Ave., Suite 316
Burlington, Ontario L7N 3P5
Phone: (905) 332-9494
Fax: (905) 332-5044

Greatario Industrial Storage Systems Ltd.
P.O. Box 3613
Guelph, Ontario N1H 6P1
Phone: (519) 763-5933

H2Flow Equipment Inc.
80 Carlauren Rd., Unit 24
Woodbridge, Ontario L4L 7Z5
Phone: (905) 264-2188
Toronto: (416) 245-7808

Heath Consultants Ltd.
2085 Piper Lane
London, Ontario N5Z 3M5
Phone: (519) 659-1144
Fax: (519) 453-2182

Hoffman Industries of Canada Ltd.
50 Bertal Road
Toronto, Ontario M6M 4M4
Phone: (416) 763-4681

Humboldt Decanter Inc.
3883 Steve Reynolds Blvd.
Norcross, Georgia 30093
Phone: (404) 448-4748
Fax: (404) 416-9377

ITTA-C Pump Canada
155 Dawson Road
Guelph, Ontario N1H 1A4
Phone: (519) 824-7750
Fax: (519) 824-7035

Indachem
86 Guided Court, Units G,H&I
Etobicoke, Ontario M9V 4K6
Phone: (416) 743-3751
Fax: (416) 743-2038

ITT Flygt
108 Skyway Avenue
Etobicoke, Ontario M9W 4Y9
Phone: (416) 675-3630
Fax: (416) 675-3636

Kenaidan Contracting Ltd.
1275 Cardiff Blvd.
Mississauga, Ontario L5S 1R1
Phone: (905) 670-2660
Fax: (905) 670-9172

Komline-Sanderson Limited
72 Orenda Road
Brampton, Ontario L6W 1W1
Phone: (905) 453-5330
Fax: (905) 453-2214

Lakefield Research Limited
P.O Box 4300, 185 Concession St.
Lakefield, Ontario K0L 2H0
Phone: (705) 652-2038
Fax: (705) 652-6441

Landry Filtration
11 Cidermill Avenue
Concord, Ontario L4K 4B6
Phone: (905) 660-1900
Fax: (905) 660-1701

Lisle-Metrix Ltd.
49 Sheffield Street
Toronto, Ontario M6M 3E5
Phone: (416) 249-9151
Fax: (416) 249-2952

M. LeBlanc & Associates
33 Elmhurst Ave., Suite 1810
Willowdale, Ontario M2N 6G8
Phone: (416) 223-7391
Fax: (416) 223-5775

Metcon Sales and Engineering Ltd.
15 Connie Crescent, Suite 3
Concord, Ontario L4K 1L3
Phone: (905) 738-2355
Fax: (905) 738-5520

John Meunier Inc.
6290 Perinault
Montreal, Quebec H4K 1K5
Phone: (514) 334-7230
Fax: (514) 334-5070

Microsep International Corporation
4599 Tillicum St.
Burnaby, B.C. V5J 3J9
Phone: (604) 432-7660
Fax: (604) 432-7412

Millennium Control Company
P.O.Box 86034
Upper Oakville P.O.
Oakville, Ontario L6H 5V6
Phone: (905) 849-0794

Appendix C-2
Members of Ontario Pollution Control Equipment Association

Milltronics Ltd.
1954 Technology Dr.
Peterborough, Ontario K9J 7B1
Phone: (705) 745-2431
Fax: (705) 745-0414

MSU Mississauga Ltd.
2222 South Sheridan Way
Mississauga, Ontario L5J 2M4
Phone: (905) 823-4340 or
1-800-268-5336

NEO Valves
430 Norfinch Drive
Downsview, Ontario M3N 1Y4
Phone: (416) 661-6020
Fax: (416) 661-6787

Nortech Control Equipment Inc.
1131 Derry Rd. East
Mississauga, Ontario L5T 1P3
Phone: (905) 564-4700 or
1-800-263-3427

N-Viro Systems Canada Inc.
2 Toronto St., Suite 402
Toronto, Ontario M5C 2B6
Phone: (416) 362-0172
Fax: (416) 362-0203

Organic Resource Management Inc.
290 Garyray Drive
Weston,Ontario M9L 1P4
Phone: (416) 747-6584
Fax: (416) 747-6899

Monsanto Enviro-Chem Systems
14522 South Outer Forty Rd.
Suite100
Chesterfield, Missouri 63017
(or) P.O.Box 14547

Napier-Reid Ltd.
10 Alden Road, Unit 2
Markham, Ontario L3R 2S1
Phone: (905) 475-1545
Fax: (905) 475-2021

Nord Gear Ltd.
20 Advance Blvd.
Brampton, Ontario L6T 4R7
Phone: (905) 792-7365
Fax: (905) 792-8522

Novamann (Ontario) Inc.
5540 McAdam Road
Mississauga, Ontario L4Z 1P1
Phone: (905) 890-2555 or
1-800-563-6266

Omega Pumping Solutions
1200 Michener Rd., Suite 6-2A
Sarnia, Ontario N7S 4B1
Phone: (519) 332-0007
Fax: (519) 332-0702

Parkson
9050 Ryan Avenue
Dorval, Quebec H9P 2M8
Phone: (514) 636-8712
Fax: (514) 636-9718

Peacock Inc.
2360 Millrace Court
Mississauga, Ontario L5N 1W2
Phone: (905) 812-7100
Fax: (905) 812-7203

Permashell Coating Services
5732 Highway 7, Unit 21
Woodbridge, Ontario L4L 3A2
Phone: (905) 850-1250
Fax: (905) 850-1252

P.J. Hannah Equipment Sales Corp.
21 Haist Ave, Unit 1
Woodbridge, Ontario L4L 5V5
Phone: (905) 850-7234 or
1-800-353-3087

Prism Resource Management Ltd.
7 Petrie Street
St. Catharines, Ontario L2P 3J6
Phone: (905) 984-8933
Fax: (905) 984-6292

Prominent Fluid Controls Ltd.
490 Southgate Drive
Guelph, Ontario N1G 4P5
Phone: (519) 836-5692
Fax: (519) 836-5226

Romatec
452 McNicoll Avenue
Willowdale, Ontario M2H 2E1
Phone: (416) 499-0222
Fax: (416) 499-0352

Pencon Equipment Company
109 Thomas St., 2nd Floor
Oakville, Ontario L6J 3A7
Phone: (905) 845-1727
Fax: (905) 845-1792

Philip Utilities Management Corporation
100 King St. W., P.O.Box 2440
LCD1
Hamilton, Ontario L8N 4J6

Power Plant Supply Company
124 Wilson St.
Oakville, Ontario L6K 3G8
Phone: (905) 845-7951
Fax: (905) 845-6695

Pro Aqua
518 Eglington Ave. East
Toronto, Ontario M4P 1N6
Phone: (416) 485-1850
Fax: (416) 485-9638

Prospec Technologies Inc.
1320 Britannia Road E.
Mississauga, Ontario L4W 1C8
Phone: (905) 795-2666
Fax: (905) 795-2775

Rotork Controls (Canada) Ltd.
5650 Tomken Rd., #1-2
Mississauga, Ontario L4W 4P1
Phone: (905) 602-5665
Fax: (905) 602-5669

Appendix C-2
Members of Ontario Pollution Control Equipment Association

Rudi Kovacko & Associates Inc.
4174 Dundas St. W., Suite 305
Toronto, Ontario M8X 1X3
Phone: (416) 234-2294
Fax: (416) 234-2295

Santaire-Water Pollution Control Corporation
9333 N. 49th Street
Brown Deer, WI 53223
Phone: (414) 365-2200

Sealpro Inc.
8 Priscilla Lane
Auburn, NH 03032
Phone: (603) 669-8786
Fax: (603) 669-9048

Sew Eurodrive
210 Walker Drive
Bramalea, Ontario L6T 3W1
Phone: (905) 791-1553
Fax: (905) 791-2999

Sodrox Chemicals Ltd.
RR#6
Guelph, Ontario N1H 6J3
Phone: (519) 837-2330
Fax: (519) 837-3300

Sterling Power Systems
799 Rennie St., P.O. Box 3313 Station C
Hamilton, Ontario L8H 7L4
Phone: (905) 547-2345 or
1-800-809-0330

Safetyscope Inc.
47 Charleston Rd.
Etobicoke, Ontario M9B 4M8
Phone: (416) 231-3752
Fax: (416) 234-1564

Schwing America Inc.
98 Mill Plain, Suite 1A
Danbury, CT 06811
Phone: (203) 744-2100
Fax: (203) 744-2837

Seepex Inc. Canada
169 Dufferin St., #18
Alliston, Ontario L9R 1E6
Phone: (705) 434-0611
Fax: (705) 434-0620

Shadrack Engineering Ltd.
501 Passmore Avenue, Unit 13
Scarborough, Ontario M1V 5G4
Phone: (416) 293-3100
Fax: (416) 293-2370

Southwestern Fluid Products Inc.
P.O.Box 28147
North Park Plaza P.O.
Brantford, Ontario N3R 7X5
Phone: (519) 751-3991

Stormceptor Canada Inc.
195 The West Mall, Suite 405
Etobicoke, Ontario M9C 5K1
Phone: (416) 626-0840
Fax: (416) 626-8710

Appendix C-2
Members of Ontario Pollution Control Equipment Association

Summa Engineering Limited
6423 Northam Drive
Mississauga, Ontario L4V 1J2
Phone: (905) 678-3388
Fax: (905) 678-0444

Systems Plus
P.O. Box 839
New Hamburg, Ontario N0B 2G0
Phone: (519) 634-5708 or
1-800-604-3645

Terratec Environmental Ltd.
P.O.Box 60069
300 North Service Rd. W.
Oakville, Ontario L6M 3H2
Phone: (905) 878-2800

Troy-Ontor Inc.
71 Cityview Dr.
Etobicoke, Ontario M9W 5A5
Phone: (416) 614-1210
Fax: (416) 614-1537

US Filter/Wallace & Tiernan Canada Inc.
925 Warden Avenue
Scarborough, Ontario M1L 4C5
Phone: (416) 751-7561
Fax: (416) 751-9682

Waterloo Biofilter Systems Inc.
2 Taggart Court, Unit 4
Guelph, Ontario N1H 6H8
Phone: (519) 836-3380
Fax: (519) 836-3381

Syntec Process Equipment Ltd.
68 Healey Rd., Unit 1
Bolton, Ontario L7E 5A4
Phone: (905) 951-8000
Fax: (905) 951-8002

Tadco Manufacturing Inc.
1239 Aerowood Dr.
Mississauga, Ontario L4W 1B9
Phone: (416) 629-9114 or
1-800-268-2309

Thyssen Marathon
2560 Matheson Blvd. E.
Mississauga,Ontario L5T 4Y9
Phone: (905) 675-5941
Fax: (905) 675-1585

US Filter/Asdor
1255 Nicholson Road
Newmarket, Ontario L3Y 7V1
Phone: (905) 836-7700
Fax: (905) 836-7720

L.E. Washington Sales Ltd.
2495 Haines Road
Mississauga, Ontario L4Y 1Y7
Phone: (905) 566-9532 or
(416) 244-5812

Westech Industrial Ltd.
240 Matheson Blvd. East
Mississauga, Ontario L4Z 1X1
Phone: (905) 890-5265
Fax: (905) 890-6213

Willer Engineering Limited
422 Consumers Rd.
Willowdale, Ontario M2J 1P8
Phone: (416) 499-4421
Fax: (416) 499-0816

Windsor Pump Co. Ltd.
2495 Laird Rd., Unit 1
Mississauga, Ontario L5L 5S5
Phone: (905) 569-9565
Fax: (905) 569-9567

Zenon Environmental Inc.
845 Harrington Court
Burlington, Ontario L7N 3P3
Phone: (905) 639-6320
Fax: (905) 639-1812

Wilron Equipment Ltd.
5195 Bradco Blvd.
Mississauga, Ontario L4W 2A6
Phone: (905) 624-8387
Fax: (905) 624-0838

Yanoshita Environmental Systems
468 Albert St., P.O.Box 28006
Waterloo, Ontario N2L 6J8
Phone: (519) 884-8599
Fax: (519) 884-7411